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Entomology in Relation to Industry

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SINCE the organization of the Association 49 years ago, with two exceptions addresses have been presented annually. Broadly speaking, these addresses may be divided into a number of groups or classes. The largest group deals with entomology in relation to the production of agricultural crops; another group reviews the past history or forecasts the future of entomological work; teaching and the training of entomologists are covered by another group; and then we have what might be termed a general group, which includes addresses on particular phases of research, entomological literature and publicity, international entomological relations, philosophical discussions, and other aspects of economic entomology. This brief review merely illustrates the breadth and scope of entomological activity since the Association was organized nearly half a century ago.

I have just said that the largest number of addresses dealt with entomology in relation to the production of crops, or the relationship of the entomologist to the actual producer, and the part that the former should play in assisting the latter to protect his crop from insect attack. The reason for this is readily understood when one reviews the agricultural history and development of this continent, which included the opening up of large areas for agriculture and horticulture, thus supplying not only ample food but also not infrequently ideal conditions for the rapid increase of insect pests. Some of these were of native origin which readily adapted themselves to the new environment, while others were invaders which had migrated to this new land in one way or another. The control of these insect attacks has been met for the most part with marked success. Economic entomology has, however, many problems yet to solve in this particular field of production, and it is only necessary to mention such problems as the control of wireworms and codling moth.

Time will not permit a review or discussion of the other groups or classes of papers, as I wish to refer to a particular phase of entomological work which is familiar to you all in more or less detail, and that is the relation of entomology to industry. Dictionaries define industry in different ways. In this particular instance I wish to exercise the privilege of making use of the term in the broadest possible sense, and refer to the fact that economic entomology is being called upon more and more to solve problems of vital importance in various fields which are not directly concerned with the actual production of a particular crop. Hence, if the use of the term is extended to extreme lengths, I trust my apologies will be accepted.

In endeavoring to point out the relationship of economic entomology to industry, on account of the limited time available it has been necessary to restrict the number of references and for the sake of convenience to group the illustrations under the industry concerned.

Entomology and land values.—The science of medical entomology has been primarily responsible for improving the conditions under which men and animals may live and thrive, and on that account has had a direct bearing on land values, thus connecting the science with the real estate industry. The control of Rocky mountain spotted fever in the western states and sleeping sickness in Africa, the tick eradication campaign in the south and the control of malaria and yellow fever in different countries, may be cited as examples. Land values will depreciate if diseases are present, making it unprofitable to carry on stock raising, or rendering it nearly impossible for the white man to survive. One of the most carefully appraised relationships of economic entomology to real estate values is exemplified by the control of mosquitoes in New Jersey and surrounding areas. The Proceedings of the New Jersey Extermination Association contain reports in this regard and Donnelly (1933), mentions that as a result of 21 years of control work, the assessed valuations in Hudson county increased by 813 million dollars, and the population registered an advance of about 25 per cent. Another striking example is the European corn borer outbreak in southern Ontario, when by 1926 not a single cornfield was fit to harvest in an area of approximately 1200 square miles. The following year corn plantings were reduced to 25 per cent of the normal in this and surrounding areas, and land values depreciated accordingly. The control of the corn borer has resulted in a return to normal plantings and property values. The same conditions apply when serious outbreaks of forest insects occur, endangering the value of properties owned or leased by lumber or pulp and paper companies.

Entomology and tourist trade.—The tourist trade on this continent has developed in recent years to such an extent that it is now termed an industry in its own right. Outbreaks of mosquitoes and black flies seriously interfere with its financial success. Great headway in the control of the former has been achieved. In the Canadian National Park at Banff it has been reported that where formerly tourists frequently left on the train following that on which they arrived, they now remain to enjoy the splendors of the views. Unfortunately, entomology has not yet suc-

ceeded in dealing with the black fly situation in so satisfactory a manner.

Metals invaded by insects.—The making of umbrellas would seem to be far removed from economic entomology, but it is only a few years ago since an urgent call was received from an umbrella manufacturer in a large Canadian city. He asked by telegraph for immediate assistance, as his employees were threatening to strike on account of a plague of "bugs" which were overrunning his factory. Prompt investigation revealed that the report was not unduly exaggerated; a species of dermestid was everywhere, and was emerging from the steel ribs used in the construction of the umbrellas. The situation was rapidly remedied by subjecting the ribs to fairly high temperatures, and destroying the beetles which had not emerged. Where or how the infestation occurred is, however, another question. The ribs were originally imported from an European country, wrapped singly in tissue paper, and then in bundles of ten covered with heavy waxed paper. Infestation must have taken place either where the ribs were manufactured or subsequently stored. The agent of the manufacturer was consulted, and careful inquiries instituted, but it was never learned where the actual infestation took place.

The literature has many references, originating mostly in the tropics, on the effects of insect attack on various metals. Insects of various orders are involved, but beetles usually are responsible for the most serious damage. Lead is the metal most frequently attacked, and includes a large number of products such as bullets, roofing, rain gutters, stereotype plates, piping, lining for vats, crucibles, fuses, batteries, etc. An illustration connecting economic entomology with the metal and telephone industries is that of the lead cable borer in California. This insect, *Scobicia declivis* Lee, bores a small circular hole in the lead cable sheathing, which permits moisture to enter, causing a short circuiting of the wires that results in stoppage of service to the public. Most of the damage occurs near the point of contact of the cable and the rings which support it and suspend the cable from the messenger strand. Covering these rings with a grease or tallow which will soften in the sun and stick to the beetle, and thus suffocate it when it bores into the cable, has given satisfactory control.

Crude oil supports fly.—Economic entomology may not have played a part in remedying conditions in the crude oil industry, but at least one of the entomological curiosities is the occurrence of the petroleum fly, *Psilopa petrolei* Coq., which lives and thrives in the crude oil pools of southern California. Howard in *Scientific American* (1899), is the first to report observations on this insect, and thus connects the science with this industry.

Insects of furs.—Furriers and dry cleaners are carrying on extensive advertising campaigns advising the public to store their furs and protect them from moths. The public, for the most part, does not realize that economic entomology is responsible for the methods that are followed in handling the furs. The two treatments most extensively used are storing the furs at low temperatures, or subjecting them to fumigation and storing in moth-free rooms. Only recently, a complaint was received from one firm which indicated that the fumigation was not effective. Sub-

sequent investigation showed that it was not the fumigation that was at fault, but the fact that the treated garments were left over night with the incoming untreated furs, and the difficulty was readily overcome by reorganizing the system of handling.

Entomological advice in mill construction.—The appearance of the alfalfa weevil in the west has been responsible for the imposing of restrictions on the movement of alfalfa hay and meal from infested to non-infested districts. Apart from controlling the weevil, economic entomology has aided the alfalfa meal industry by assisting in designing alfalfa meal mills, whereby particular attention is paid to the routing of the hay through the mill so as to prevent the milled meal coming into contact with the incoming, possibly infested, hay. As a result the industry is naturally benefited, in that it is now possible to distribute the product in areas which heretofore were restricted.

Insects infecting candy.—The humble five-cent chocolate and nut-meat bar has developed into a major item of business in the candy industry, and the manufacturer is suffering heavy losses due not only to returns on these items on account of insect infestation, but also to law-suits instituted by individuals who claim subsequent illness as a result of eating infested bars. Economic entomology has helped the trade by pointing out to the manufacturer the necessity of keeping his factory clean, treating for insect infestation not only the raw products such as cocoa beans, nutmeats and dried fruits, but also the finished product in the outgoing package. This, the manufacturer claims, is not sufficient, for he maintains that infestation in the bar may occur either in the jobbers' warehouse or in the showcase in the retail store. He is now asking for an insect-proof wrapper at reasonable cost to protect not only his product, but also the trade name. A considerable amount of work has already been done on this particular problem, but so far as I am aware the desired results have not yet been obtained.

Dairy-product industries affected.—The dairy industry has received help in milk production by the development of fly repellents and the treatment for warble flies, etc., and various allied industries are turning to economic entomology for assistance. Not very long ago a number of dried-milk plants reported that they had received complaints about their finished product being infested with dermestids, and they were threatened with loss of trade and markets. Investigation showed infestation in several plants. Advice was given with regard to control, which proved effective. Although not definitely proved it may be of interest to mention that the cause of infestation was due most probably to the imported waxed paper liners for the barrels. A somewhat similar case occurred in an allied industry. The manufacturers of an internationally known invalid and childrens' drink, which used dried milk as the base, had received serious complaints about dermestids being found by the consumer in the sealed cans. A careful and thorough check-up of the plant was made without result, and the only possible source of infestation remaining was the tin container, which was received in fibre cartons and without lids, from a large tin-can manufacturing factory. Hundreds of empty

cans were examined and then the odd dermestid was found. Later investigation revealed the beetles in very limited numbers in the corrugated cartons. To avoid further trouble, all empty cans and cartons were fumigated under vacuum before being shipped to the establishment where the prepared drink was made.

The presence of skippers in certain varieties of cheese may be welcomed by individuals who consider themselves connoisseurs, but this does not apply to the manufacturer of processed cheeses who, when he examines his storerooms containing $200,000 worth of cheese, finds it seriously infested with mites, which ruin its appearance by causing a breakdown and discoloration. In desperation, he may turn to the economic entomologist for an immediate solution of his difficulty, and is agreeable to do anything which will destroy the mites, and yet not affect either the color or flavor of the cheese. Unfortunately, it is not always possible to recommend a solution to such a problem without experimentation, but it may be possible to point out that it is unwise to try to hasten the curing of the cheese by raising the temperature and humidity to such a point as will provide optimum conditions for the multiplication of mites.

Entomology and cosmetics industry.—Newspapers in all countries are continually carrying reports from bureaus of statistics which point out with more or less consternation, to the ever-increasing sums that are being spent on cosmetics, perfumes, lipsticks, etc. One of the ingredients that went into these preparations as coloring, before the extensive use of analine dyes, was cochineal. The development of this industry, that is, the utilization of the dried scale insect, *Coccus cacti* L., dates back to the time of the Aztecs, whom we might regard as potential entomologists. Many years ago the *Opuntia* plant, the host of the cochineal insect, was introduced into Australia in an endeavor to obtain an independent supply of what at that time was an extremely valuable product. Unfortunately, the plant readily adapted itself to the new environment, spread at the rate of 800,000 acres a year, and has invaded large areas of arable and grazing lands. Economic entomology is now playing an important and unexpected role in the control of this plant pest. Although different methods have been tried to bring it under control, the introduction of various species of insects which feed solely upon the plant is one of the most important.

Apart from the above, I have been unable to locate any reference to economic entomology being of assistance to the perfume industry, whereas the industry is of great benefit to the science, by the use of some of the essential oils such as eugenol and geraniol which are utilized as attrahents for the Japanese beetle. However, I have not given the case up as hopeless, for after all as the perfumer makes use of the Asiatic musk deer for his musk sac, why should he not find some use for our old friend the stink beetle, *Nomius pygmaeus?* I feel sure the entomologists would not have much difficulty in furnishing a supply of material!

Insects of wood and paper.—Apart from the practises of the forest entomologist in protecting the growing timber, the lumbering, building,

pulp and paper industries have benefited greatly by the application of entomological knowledge. The extent and importance of this cannot be overestimated, and a great many examples should be mentioned, but the limit of time and space makes it possible to refer only to a very few. The work that has been done to protect buildings from termite attack; the reconstruction and preservation of historic and other structures from the ravages of the "death watch" and other different species of wood-infesting beetles; the preservation of construction timber, poles and railway ties, etc. with creosote or similar chemicals under vacuum, or the use of other processes to protect them from insect attack; and the treatment, as a safeguard, of papers, books and documents, and even wall board, the latter a by-product of the pulp industry, cannot be more than alluded to. Reference should be made to the export lumber trade and the necessity of meeting the requirements of certain countries to prevent the importation of species of bark beetles, etc. Even the types of wood used in the construction of containers is one in which the science is concerned, and the precaution of treating the wood to prevent the introduction of new and potentially dangerous pests may be necessary. As an example, at one of the larger Canadian seaports it has been found that approximately 40 per cent of the containers constructed of ash with the bark on, and used for crockery imported from Europe, was infested with the scolytid *Leperisinus fraxini* Panzer.

Strict maintenance of the gypsy moth quarantine, which includes the inspection and certification of commodities, is responsible for the development and extension of markets for a number of industries not only connected with the lumber industry such as cordwood, poles, ties, telephone reels, etc. but also Christmas trees, paving stones and even monuments for cemeteries.

Insects in stored products.—In the field of stored products which affects so many industries, economic entomology has been responsible for maintaining the trade in the distribution of products from one country to another. The literature is so full of references estimating the amount of damage caused by insects to different commodities that it is unnecessary to review the question at this time. It may be of interest, however, to refer very briefly to a paper presented by Munro before the Royal Society of Arts (July 1936), in which he pointed out the condition of British Empire products arriving at the port of London. With the exception of tea, practically all products have suffered more or less severely from insect attack, particularly cocoa, dried fruits, nuts, spices, tobacco and grain. In 1929 and 1930 the losses to African leaf tobacco due to *Ephestia elutella*, were from 40 to 50 per cent, and amounted to half a million dollars. Australian dried fruits suffered so severely from infestation by *Plodia interpunctella* in 1932 that it was almost impossible to market the fruit. These conditions can and have been remedied by the application of control methods which are already known to the science and which are rapidly being improved.

Entomological inspection of ships.—The treatments used for the control of insects in flour mills are well known, and it frequently becomes necessary to treat the flour itself. There has been a marked expansion

and therefore keen competition in the export trade in flour, which is now shipped to all parts of the world. Importers sometimes complain of the condition of flour on arrival, or after being held in storage for any length of time. This has necessitated not only the sampling of flour as it leaves the mill and at destination, but also the examination of vessels before the flour is loaded, to determine whether they are free from insect infestation. It has also been necessary for entomologists to accompany shipments, examine the flour from day to day in the ship's hold, record the variation in temperature and humidity, and the conditions under which it is stored at the port of arrival. Even with these precautions the case may not be closed, for it has been found that the fumigation of flour with certain gases to destroy insect life may result in its breakdown and injure its baking qualities if it is not used within a reasonable period of time. All of which merely illustrates the complexity of apparently simple problems, such as the fumigation of flour, and the necessity of further extensive work.

The importance of having vessels examined by a trained entomologist previous to loading with flour is illustrated by an incident that occurred recently. The inspector had completed his task, reported the ship as clean, and returned to headquarters. Within less than a day a telegram from the ship's agents arrived, stating that the vessel was "alive with bugs." The inspector returned and found the vessel to be overrun with the clover root curculio, *Sitona hispidula* Fab., and the clover leaf weevil, *Hypera punctata* Fab., which apparently had descended on the decks in a shower just prior to a light fall of rain. The correct identification of the insects by a competent authority avoided what might have been a serious dispute between the exporter and the owners of the vessel.

Processing methods of industries.—The development of what might be termed "processing methods" to destroy insect life in various commodities has been of inestimable value to a wide range of industries, and has opened up for them new and more extensive markets which were heretofore closed. Among the materials subjected to processing either by sterilization, fumigation or subjection to either high or low temperatures, may be mentioned the treatment of broom corn for the European corn borer and other pests, green sweet corn on the cob for the former insect, cotton for the pink boll worm, blueberries for the Japanese beetle, potatoes for the potato tuber moth, and citrus fruits and grapes for different species of fruit flies.

Entomology's influence on trade.—The saving in time that has resulted from the evolution of the express ocean liner and the clipper ship of the air may possibly be of benefit to man, but, on the other hand, these means of rapid transportation have increased the insect menace in that they afford greater opportunity for the transportation of perishable products and the pests they may contain. To safeguard themselves from further invasion of injurious insects, more and more countries are placing embargoes or restrictions on the importation of such commodities, and extensive markets are becoming constricted. Economic entomology has, I believe, an excellent opportunity to meet these conditions and pave the way for the development of international trade. The recent

improvements that have been made in vacuum fumigation equipment, and the discovery of new fumigants which will not affect the appearance or flavor of the commodity treated, or leave residues injurious to health, and yet be 100 per cent effective in destroying any insect life that may be present, open up great opportunities in this connection. Undoubtedly, if processes were developed which would enable the exporting country to treat fresh fruits and vegetables, plant products and even plants without injury, and at the same time guarantee freedom from insect pests, many trade problems would be solved, markets now closed would be opened, and the industries concerned could reap the harvest. When that time arrives, an incident such as the following may become a part of entomological history.

On March 23, 1934, there appeared in a Toronto paper a report to the effect that the Franco-British trade negotiations conducted in London had ended abruptly and that the French Minister of Commerce with his party had returned suddenly to Paris. The failure of the conference was not due to any difficulty in the solving of tariff problems, but because there seemed to be no way of circumventing the Colorado potato beetle situation in connection with the importation of French farm products into Great Britain.

Unquestionably, many other examples illustrating the relationship of economic entomology to industry will have entered your minds. On the other hand, I am hopeful that the references that have been given indicate to some extent the tremendous increase in scope in entomological activities that has occurred in recent years.

Possible future relationships.—In many of the earlier addresses the future of entomological work has been discussed. I trust, therefore, that it will not be considered inappropriate to say a few words along these same lines at this time. Howard, in an address on "Entomological Needs of the World," spoke of the rapidly increasing appreciation by the intelligent public of the tremendous importance of entomological work; and that the insect problem is becoming increasingly more serious in spite of the fact that during the last 20 years the number of workers has doubled, and entomological appropriations trebled. All entomological workers will, I think, agree without hesitation with this statement. The orchardist realizes that he cannot produce a commercial crop of apples without the aid of the economic entomologist and his colleague the plant pathologist, and other industries are just beginning to realize more and more the necessity of applying entomological knowledge. In fact, industry, apart from calling for aid, is coming to the assistance of the entomologist by establishing research laboratories to investigate and develop new materials which may be used to combat insect attack. Such are the facts, and it would appear that economic entomology as a science is just beginning to emerge in a world that, as time goes on, will as never before realize the part that insects play in our lives and the war that man will have to wage against them.

Broad cultural training needed.—Sir Robert Borden, a former Prime Minister of Canada, has said that this is the century of dynamic trans-

formation, which means that economic entomology with the other sciences and industries will have to forge ahead in order to compete with these new conditions. How can the entomologist of the future prepare himself to face these changes and rapid developments? The many papers that have been presented before this Association on the training of entomologists have practically without exception emphasized the necessity of a broad basic training, and this to my mind is the solution, a training broad not only scientifically but also culturally.

For many of us now engaged in the work it may be too late to make radical changes, and we have not the opportunity to live our lives over again, but we do envy the opportunity of those who, following in our footsteps, are enabled to benefit by the mistakes that we may have made.

Economic entomology has produced great leaders in the scientific world—men of vision and of genius—but the entomologist of the future, irrespective of whether his chosen field be in research, administration or of a regulatory nature, must, in order to prevent the science being submerged, be prepared to lead the way to an even greater extent than in the past. When that call for leadership comes, it is to be hoped that he will not be handicapped in accepting the call by either lack of training or breadth of vision.—1-7-37.

Symposium: Insects Affecting Man

L. O. HOWARD, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, Washington, D. C., Chairman*

I have not words to tell you of the pleasure and pride that I feel in having been the choice of the Committee on Program to be the chairman of this important symposium on medical entomology. The importance of this function rests partly upon the importance of the subject and partly on the very high standing of the speakers chosen. Each one is a shining light in the branch of the subject upon which he is speaking. And this holds equally as well for the ones who have been chosen for the leaders in the discussions.

In considering the speakers the thought enters my head that the rapid and very great development of the subject has not only been a splendid thing for entomology but it has added very greatly to the number of entomologists. Who shall say how many medical research men, doctors of medicine, have become entomologists in a sense? Surely the importance of the entomologist has been vastly increased. I wish to call your special attention to the fact that no less a person than Dr. L. L. Williams of the United States Public Health Service, the leader in the great malaria control work of that organization, has become deeply versed in mosquito work and is on our list of speakers. The two great entomological societies that have sponsored this symposium should be very proud of the fact that each of those participating is a recognized leader in the field upon which he addresses us.

We are meeting in an historic place. I do not refer to past history—to the neighborhood where George Washington crossed the Delaware or to the Trenton battlefields or to Valley Forge or to Philadelphia, the home of the Continental Congress; but to much more recent history. I refer to Atlantic City, the familar scene where for the past 15 or 20 years have been held the annual meetings of the New Jersey Mosquito Extermination Association, most of these meetings in this very room. The proceedings of this Association, as you may know, are read with the greatest interest in all parts of the world. It is, therefore, highly appropriate that the first speaker in this symposium should be Dr. T. J. Headlee, the entomologist to the state of New Jersey and the secretary of the New Jersey Mosquito Extermination Association for many years. No one can speak more authoritatively than this man on the subject of mosquito control.

Mosquitoes and Their Control

THOMAS J. HEADLEE, *New Jersey Agricultural Experiment Station, New Brunswick*[1]

From the title of this paper, when taken in connection with the symposium of which it is a part, it is obvious that it is to be concerned primarily with pest mosquitoes. With very few exceptions all female mosquitoes are pests. Some of them, in addition to being pests, are demonstrated carriers of human and animal disease. Pest mosquitoes in the narrow sense are, therefore, those mosquitoes which bite humankind but do not in this biting act as vectors for disease-causing pathogens.

Nature of and extent of damage done by pest mosquitoes.—Pest mosquitoes are injurious to humankind primarily through direct biting and withdrawal of blood from man and from his domesticated animals. The damage accomplished is proportional to the density and to the sensitiveness of the individual. In the process of biting, insect secretions are injected into the wounds causing irritation. In some people this feeling of irritation is accompanied by swellings of greater or less size. In others no swellings whatever make their appearance. The same person may at the outset of the season respond to mosquito bites by formation of weals of considerable size and later in the season exhibit no swellings whatever where bites have taken place. The writer has met very few persons who claimed that the bite, whether it causes swelling or not, is without irritation. Some people do not know when they are bitten. Some people are practically never bitten. Naturally the first case is to be attributed to lack of sensitivity and the second case to the presence of mosquito-repellent conditions characteristic of the individual's body.

Communities that have developed in the presence of dense mosquito pests, increase in population either slowly or not at all, because, while the natives of the particular pest-mosquito-ridden area accept the mosquito as one of the inalienable conditions of life, people from the outside in

[1] Paper of the Journal series, New Jersey Agricultural Experiment Station, Department of Entomology.

less mosquito-infested areas will not come into the infested area or having come in will get away as promptly as possible. These conditions are best exemplified in various areas at the seashore within easy reach of large populations of people where, because of relief from summer heat, bathing, fishing and sunning, thousands of people would normally spend their vacations. No matter how great the natural vacation attractions are, if the place is mosquito-pest-ridden the number of people spending vacations at that place is always greatly reduced and in many cases rendered negligible.

It is a somewhat difficult matter to measure the effect of great pests of mosquitoes upon areas naturally very attractive to the summer vacationists. Thinking that such conditions might be reflected in taxable values, some years ago the writer made a study of increase in taxable values in such areas in comparison with areas from which the mosquito pest had been largely removed and for sake of completeness made the further comparison with areas in which the mosquito pest has never been a matter of serious moment. The period studied extended from 1900 to 1925 and the area involved consisted of all New Jersey boroughs and municipalities bordering on the salt marsh or containing salt marshes. Limiting the study to the areas bordering on the salt marsh it was felt tended to make the figures conservative because the benefits of mosquito elimination extend for many miles inland from the salt marsh.

In all those areas in which the mosquitoes were as much of a pest as they had always been the increase in annual taxable values from 1900 to 1915 inclusive, was $1,228,000, while in the succeeding 10 years the annual increase in taxable values in the same areas was $1,174,000. Thus the record of tax increase in the two periods in areas ridden by the mosquito pest showed less of an annual increase in the last 10 years than that which had occurred in the preceding 15. We will now examine what occurs in the areas in which the mosquito pest was largely eliminated throughout the last decade in the same period and the areas in which the mosquito pest has never been seriously troublesome. In the areas where the mosquito pest was largely absent throughout the decade from 1916 to 1925, the yearly increase in taxable values during the first 15 years, namely from 1900 to 1915 inclusive, was $64,920,000, while during the 10-year period following the increase was $113,250,000. The average annual increase during the 10-year period is thus seen to be almost twice as great as the average annual increase during the 15-year period. In the area where the mosquitoes have never been seriously troublesome the average annual increase in taxable values from 1900 to 1915 inclusive was $16,690,000, while in those areas in the following 10 years the average annual increase was $25,200,000, or somewhat less than twice as great.

Thus it appears that in mosquito-ridden areas the rate of taxable value increase is decidedly held down, while in areas from which the mosquito pest has largely been eliminated the annual taxable value increase is much accelerated and that the acceleration visible in mosquito-freed areas is paralleled by the rate of tax value increase in areas which have always been relatively free from the mosquito pest. Extending this

relationship to figures we find in the area in which the mosquito pest had originally been very bad and from which by 1916 it had practically been eliminated, that the actual gain in taxable values during the 10-year period from 1916 to 1925, by reason of this elimination, was $483,300,000.

Ecological conditions necessary for pest mosquito production.—Like all cold-blooded organisms, temperature of the environment controls metabolic activity of the mosquito. When the weather is cold there is little or no activity of this sort. When the weather is warm there is great activity. When the weather is too hot reduced activity again appears. The same development which in midseason of high temperatures will require a week, in the spring or fall will require three or four weeks. Winter temperatures always produce a great reduction in those species wintering over in the adult form, some reduction of those wintering over in the larval form but appear not to reduce to any appreciable extent those that pass the winter in the egg form. Consequently the first mosquito broods of size in the season are those which come from eggs or larvae that have wintered over and it is only as the season grows much older that great broods of the forms which winter over as adults make their appearance.

All mosquitoes must have water in which to breed. This water must be favorable to the development of unicellular plants and animals or the mosquito larva starves to death. It must remain for a sufficiently long period for the mosquito larva to complete its development or the mosquito wriggler dries up and dies. This water must contain no seriously toxic or deleterious substances or the mosquito wriggler is killed. Some species are tolerant of different degrees of sea salts. Eggs, which will not hatch in the presence of a reduced amount of sea salt, will hatch when greater concentrations appear or eggs which will not hatch in great concentrations will hatch in low concentrations. Consequently, in the spring when the concentration of salt of the salt marshes is reduced by reason of rain and snow waters, *Aedes cantator* hatches and develops. Later in the season *Aedes sollicitans*, which is more tolerant of salt concentrations, takes its place. The same salt-marsh pool may produce *cantator* in the spring and *sollicitans* from midseason on. Throughout the season the upper reaches of New Jersey rivers emptying through the salt marsh will show the development of *Aedes cantator* while the lower reaches of the salt marshes themselves will show this species in the early season only followed by the development of *Aedes sollicitans*. When a salt marsh is diked and tide-gated it tends to lose its salt content and this change may continue to a point that not only *Aedes vexans* will breed abundantly but *Culex pipiens* breeding will become common. There are pools of water in which mosquitoes do not breed. This has been shown by Rudolfs (1926) to be due either to the presence of toxic substances in the water or to the type of anaerobic digestion occurring in the bottom of the pool. Mosquito-breeding waters must be free of wriggler-eating fish and possibly other predaceous and parasitic forms concerning which we have inadequate knowledge or they cannot support the development of broods of mosquitoes.

Likelihood of distribution.—It appears to be an established fact that mosquitoes distribute themselves on the wing. Salt marsh forms show records of as much as 60 miles. The dominant freshwater swamp mosquito, *Aedes vexans*, has a proved range of 10 to 15 miles and the house mosquito, *Culex pipiens*, has been shown definitely to migrate 2½ miles. The length of movement is somewhat proportional to the density of the brood. The greater the density the further it appears to move. Salt marsh mosquitoes apparently move with the wind. Fresh-water swamp mosquitoes and the house mosquito appear to move in direction of populations. Rudolfs (1922) has shown that there is nothing more attractive to the female mosquito than the warm moist breath of the individual and Headlee (1932) has shown that the evolution of carbon dioxide for two hours during the most favorable catching period of the day over the mosquito trap increases its catch by as much as 800 per cent.

It is a well-known fact that mosquitoes ride on shipboard, in trains and in airplanes. Artificial distribution is, therefore, going on throughout the mosquito season or seasons.

Problems of controlling pest mosquitoes. GENERAL.—In general, problems of controlling mosquitoes involve the selection of the vulnerable stage or stages and the use of physical, chemical and biological methods.

It seems reasonable that historically the first attack upon the pest mosquito consisted of squashing the biting females and repelling them with smokes and vapors. The modern counterpart of this attack upon the adult appears in the utilization of the New Jersey larvicide for protecting small or large aggregations of people who, for one reason or another, wish to hold outdoor meetings in mosquito-infested territories. This method has been developed to an extent where we are now able to say that it is practical and useful. Audiences consisting of as many as 20,000 people have been fully protected by the proper use of this larvicide prior to the opening of the meeting and at certain times during the meeting.

Because mankind did not readily connect either the egg or wriggler with the buzzing, biting mosquito, it was not until recent times that any effort was made to attack the mosquito through destroying these immature stages.

Attack upon the egg, particularly of those species that lay their eggs in the soil, has begun as a subsidiary mosquito control process and it has become the practice, using waste lubricating oils, to treat the sloping borders of pools and the empty temporary water-holding depressions during the nonbreeding season with oils of this character. A great disadvantage in the process lies in the destructive effects of this treatment upon the vegetation and consequently upon the appearance of treated places. This disadvantage is a very serious one in highly populated districts and is certain to continue to form a limiting factor in the application of this method.

With the discovery that mosquito larvae and pupae could readily be killed by placing kerosene on the surface of the water in which the wrigglers were living and growing and the realization by advanced thinkers

among the public that if all mosquito-breeding waters were thus treated the mosquito pest would disappear, mosquito control activities were shifted to this field of endeavor and for a period of 35 years or so have been centered upon this line of attack. The strategy in mosquito warfare has long been based on the principle that inasmuch as all mosquitoes pass an essential stage (the wriggler) in water the elimination of all such mosquito-breeding waters by removal or by treating in such a fashion as to render them unsuitable for mosquito brood development is followed in due course by the elimination of the mosquito pest. This principle is still basic for the great bulk of the mosquito control work in this country today.

Physical methods against mosquitoes are as old as the human race and in many instances are the only methods still practiced. The early physical methods included squashing of the biting females. Today, accepted physical methods consist principally of removal of mosquito breeding waters by drainage or filling and the building of dikes, dams and gates for the impounding and manipulation of water. The use of mosquito extermination traps, as has been practiced in some parts of France, must also be classed under this head.

Chemical methods include the use of larvicides of various forms and repellents of various kinds. The commonest larvicide is, of course, fuel oil but fuel oil has the disadvantage of being injurious to fish, waterfowl and aquatic plants. Ginsburg (1935) by reducing the amount of oil to not more than 3 gallons an acre and impregnating it with pyrethrins has been able to form an efficient larvicide at about half the price of fuel oil and which is not injurious to fish, waterfowl and aquatic plants. It has been shown that the distribution of Paris green as a dust on the surface of mosquito-breeding waters readily destroys those mosquito larvae that have the surface-feeding habit but it has also been shown that the same process is ineffective in dealing with the subsurface feeders. Furthermore, the use of arsenicals of any kind on potable waters, while these waters are being used for human consumption, is very largely out of the question. Many other chemicals have been used and have been shown to kill mosquito larvae but either their toxicity to man and animals or their cost has rendered their employment impracticable. There is, of course, the undeveloped possibility of treating pools and pool bottoms with chemicals to prevent the development of mosquito larval food.

The only natural enemy of really great importance in mosquito control is the wriggler-eating fish. Where an abundant supply of these fish is available and can reach all parts of mosquito-breeding waters practically no mosquitoes reach maturity. Many other natural enemies have been cited, including bats, insectivorous birds, mites, round worms and certain protozoa. None of these, however, has ever been successfully used for mosquito control. For a time the use of bats was widely advocated but from all reports which the writer has examined their utilization appears to be more or less of an idle dream. Nevertheless, it is possible that we would have far more of pest mosquitoes in this country if it were not for the work of these obscure natural enemies.

SPECIFIC.—In dealing with mosquito control specifically the first problem is to obtain an accurate knowledge of the mosquito fauna of the district to be protected. This is best obtained through the agency of a mosquito trap survey. Traps are set nearby or among shrubbery in the backyards of towns and cities of the area. The number of traps utilized is variable, depending upon the nature of the terrain. More traps will be necessary in a town or city located among the hills than in a town or city located on a flat plain because the hills interfere with the normal distribution of the insects on the wing. It is usually sufficient to trap for one full mosquito season because it is rare that the species composing the fauna do not at some time in a season make their appearance. For the sake of understanding the time of appearance of the different components of the fauna it is advisable to keep each night's collection separate from the others. A record of species and numbers representing them should be carefully made. With these data in hand the entomologist should be able to form an excellent and reasonably accurate picture of the mosquito fauna of the district. Should these trap records show the presence of species the breeding of which experience indicates does not occur in any of the breeding places within the protected area, a case of migration has appeared and it becomes necessary to trace the source of this migration immediately in order that the factor of migration into the protected area from the outside may be evaluated and taken into consideration when the plans for practical work are being formulated.

The second problem in mosquito control is the formation of an organization for carrying out the practical work. In this problem there are several important factors. First and foremost, a mosquito man, that is a man who understands the habits and activities of mosquitoes, must be secured to head the work. The problem of mosquito control is a biological problem and only to a very limited extent engineering in nature. The engineering involved is ordinarily very simple while the biological phases of the problem are sometimes very complex. Naturally, the mosquito executive must have the ability to pick satisfactory help, must be able to maintain a proper contact with the people being served and must be free from so-called political interference. Without doubt moneys used for mosquito control are properly drawn from taxation because the results of mosquito control are participated in by all persons living in the protected districts. An unpaid body, representing the people of the protected district to whom the mosquito executive is responsible, is, the writer believes, a necessary provision. When the protected district is menaced by migrations from outside its boundaries it becomes necessary either to increase the size of the area to be protected to include these sources or to have work undertaken outside the area for the purpose of controlling such broods.

It is a matter of extreme importance to be able to measure with reasonable accuracy the results of practical antimosquito work and it is thought that the most satisfactory measure of this sort can be found in the determination of the composition and density of the mosquito fauna in the protected district. This determination should begin with the appearance of mosquitoes and should not close until the weather grows too cool for

mosquito activity. Here again the mosquito trap is an invaluable instrument and costs for its establishment and operation only a small percentage of the total moneys involved in carrying on the practical work.

A review of certain correlations between the number of female mosquitoes taken in traps and human discomfort should be interesting and worth while. At the outset of most mosquito projects the first criterion of results is the presence or absence of complaints by citizens. Experience over many years of practical mosquito work indicates that such complaints come usually when mosquitoes are sufficiently abundant to penetrate the houses and give trouble to the occupants at night. A protected community can have a high population of mosquitoes and yet be practically free of such complaints. Then comes the stage at which the protected population demands freedom from mosquito biting on its unscreened porches during warm evenings. It has been found that a mosquito trap properly placed can catch as many as 24 female mosquitoes and the desired porch freedom be secured. This is about the point where most mosquito control work is at the present time. In the future, however, the demand of the householder that he be able to work his garden in the dusk of warm evenings without being bitten by mosquitoes is at hand. Experience with the traps indicates that not more than five female mosquitoes can be caught per trap per night and give this degree of mosquito freedom. Most of us are still far short of bringing mosquito control work to the level of this criterion.

Rainfall has much to do with the mosquito control problem. It is not alone the water which falls at any one time that creates pools from which a great brood of mosquitoes escape but the distribution of rainfall in relation to the question of maintaining pools established long enough for a mosquito brood to develop. Rainfall which creates hundreds of thousands of temporary pools and which comes frequently enough to maintain them over a sufficient period of time is the condition which constitutes the maximum load of mosquito breeding and it is rare indeed that any mosquito fighting organization finds itself competent to handle the mosquito problem fully under this set of conditions.

Public Relations.—Mosquito control is a problem of serving the public. The public must, therefore, be kept interested in it. Lectures, newspaper articles, radio talks, special courses, exhibits and every possible means of interesting the public in the work must be carried out. Most mosquito control work exhibits far more failures in public relations than in practical technical work. It sometimes seems to the writer that 75 per cent of the executive's time and effort must be given to this problem and 25 per cent to the technical work. Perhaps these figures are too large but experience seems to bear them out. Occasionally, the mosquito executive runs afoul of some special interest which it may be difficult to adjust. One of the recent cases of this kind is the propaganda for the preservation of wildlife. While it is absolutely an historical fact that to a large extent civilization represents the results of man's struggle to control biological and physical factors of his environment, the wildlife propaganda appears not to distinguish between preservation of those forms

of wildlife that are seriously injurious and those forms that are beneficial. Individual proponents of wildlife preservation in some cases seem to recognize this distinction but the propaganda as the writer has seen it does not seem to do so. All this experience reinforces the contention set forth above, namely, that the public being served must be kept thoroughly informed and interested in the needs, the progress and the success of the service.—1-11-37.

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Mosquito Control and Wildlife Conservation

Two Distinct but Sometimes Overlapping Systems of Processes in Human Ecology

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In opening the discussion of Dr. Headlee's paper, it may be helpful to sketch in simple outlines a background against which the paper just read and the discussion that is to follow may stand in clear perspective.

As Dr. Headlee has indicated, mosquito control procedures and methods of securing a check upon the effectiveness of such work or of determining and correcting any sources of failure have attained a very satisfactory state of development. Yet there are many problems that remain still to be solved concerning refinements in the adaptation of control procedures or of combinations of procedures to special conditions. Particularly urgent among the more recently materialized problems of this character are those which have to do with the subdivision treated by Dr. Headlee under the head of "Public Relations," and which have centered very largely about the relation of mosquito control procedure to wildlife conservation. As a keynote for the discussion therefore, I shall take the fact that "mosquito control" and "wildlife conservation" are two distinct, but sometimes overlapping series of processes in the all-inclusive interactions of human ecology, or of human biocoenology if one should prefer that term.

Prior to the advent of civilized man the plants and animals of our North American continent, in their systems of adjustment one to an-

other and each to the physical factors of its own peculiar environment, had arrived at an approximation of equilibrium within the pattern of which the most extreme oscillations that were likely to be set in motion rarely constituted more than a local menace to the continued existence of any species. Progressive changes in the physical environment were relatively slow, affording ample time usually for the species concerned to make any necessary readjustments in the resulting ecological successions.

Through the progressively growing complexities of the social structure called civilization, however, "modern" man has become an ecological cosmopolite with an exceedingly complicated intraspecies biocoenology of his own; and the relatively sudden and all-pervasive intrusion of this changed and now almost universally dominant human factor has thrown the former system of relative order into a state of ecological confusion that has been almost catastrophic in many of its ecological consequences.

The complicated, diverse and often mutually antagonistic behavior patterns that characterize civilized man have largely been acquired very recently in the course of human evolution. These recently acquired and highly specialized behavior patterns often exhibit disharmonies and errors of coordination, and ecological incongruities that have introduced many new and profoundly discordant elements into formerly balanced systems of interactions, not only between man and various factors of the general environment, but also within the intraspecies ecology of modern man as well.

For example, one portion of a human population may demand the suppression of mosquitoes on the ground that they are a menace to life, to health and to comfort. Mosquitoes can develop only in aquatic environments appropriate to the species concerned, and the suppression of these insects may be accomplished by bringing about some change in their essential environment that will render it no longer suited to their requirements. But other portions of the human population, variously concerned with the sport of hunting waterfowl, with the preservation of non-game birds for their aesthetic value, or with the preservation of rare plants or of special plant societies and the like, may become genuinely concerned and may conscientiously oppose those types of mosquito control procedure which might adversely affect their own special interests.

Wildlife conservation and mosquito control, therefore, are relatively small sectors, each in a different and very wide front of human activity. Yet these two sectors like the major fronts to which they belong are tied together by the tissue of interacting physical and biological factors of which they are all a part.

More than any other organism, modern man possesses the power to exploit his environment, or to remold it at will; and his use of this power may be either destructive or constructive.

In the random exploitation of his environment by modern man, the conversion of land and water areas to special uses, disregard for the effects of wastes from human communities and special human activities,

and the absence of any planned system of control adjustments to compensate for the changed relations of man to his wild fellow creatures, have converted many formerly populous plant and animal habitats, some unavoidably but too many needlessly, into biologically depleted, or biologically desert areas.

In the purposeful remolding of his environment man has become highly successful in the suppression of antagonistic organisms. With smaller forms this is variously accomplished by the introduction into the environment of some barrier or some lethal factor; or by changing the environment so as to turn the biological balance against the unwelcome organism, or otherwise to render the environment no longer suited to it. Mosquito control lies in this general field; and an environment that is materially modified with reference to one organism or group of organisms is at the same time modified in some degree either favorably or unfavorably with reference to all of the associated organisms.

The relatively new wildlife conservation movement is an effort to assume control of, and to bring some degree of order into the confused jangle too often of viciously antagonistic interactions that have been set in motion by the influence of civilized man. Some objects of this movement are, through planned systems of controlled adjustments, to check the most destructive of these interactions; to repair some of the damage that has already been done; to examine rigorously all new factors that may cause unnecessary future harm; and where human welfare and the welfare of any of our wild fellow creatures are unavoidably in conflict, to bring about a reasonable adjustment of the situation that will result in the least possible harm to wildlife.

Intelligent and effective planning for the accomplishment of these ends is possible only when it can be based upon sound scientific knowledge of the various factors and processes that are concerned. Any sound adjustment of the processes involved in mosquito control procedure to the problems of wildlife conservation must take into account the scientific information produced by just such thorough investigations of marsh ecology as those outlined in the paper just read. It is fortunate that studies of this kind are in progress or contemplated in several states, and by the federal agencies concerned with mosquito control work and with wildlife conservation. Every effort should be made to advance these studies, and to coordinate and weld the various units into a comprehensive program. But in our discussion of ways and means we should not overlook the fact that there is also a very large field of general human ecology which must be taken also into account before the best possible solution of this group of problems can be attained.

As a starting point for discussion, we may safely assume that popular demand is going to require the suppression of pest mosquitoes not only within flight range of urban and residential areas, but with flight range of many seaside and mountain recreational areas as well; and this popular demand will just as inevitably require the suppression of mosquitoes in any wildlife sanctuaries or game preserves that may be within flight range of such areas.

This is not a matter of choice either with mosquito control workers or with wildlife conservationists. It is simply one of the trends in human ecology that neither group could turn aside if it would.

Instead of bickering over minor local problems, therefore, far-seeing biologists (including mosquito control workers) should canvass the problem thoroughly from the standpoint of long-time planning; and this should be done as a part of, or in close coordination with the admirable program of national, state and local planning that has advanced with such rapidly increasing momentum during the last few years.—1-11-37.

Mosquitoes and Malaria

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Though we frequently induce therapeutic malaria as a treatment for paresis by an artificial inoculation with malarial blood, the only known vector in nature is the mosquito. The only genus capable of transmitting the disease is *Anopheles*. This mosquito must acquire the plasmodium from an infected individual and must incubate the organism for not less than 12 days before it can transmit the disease to another person. The epidemiology of malaria depends principally upon the habits of the mosquito and to a lesser degree upon the habits of man.

The habits of man vary widely geographically, racially and economically, whereas the habits of the mosquito vary largely by species. In the temperate zone, where the transmission season is short, malaria tends to disappear among a people of high economic status who do not work to exhaustion daily, who live comfortably, and who are well housed and well fed. No amount of good living and good eating, however, can protect a group of people who live in the tropics amongst a highly infected people.

The distinctive habits of the various species of *Anopheles* must be known if breeding of these mosquitoes is to be prevented. For instance, in the Federated Malay States *Anopheles umbrosus* is the vector in the coastal plain, breeding in practically stagnant water densely shaded by mangrove. Its production is controlled either by clearing the swamps and letting in the brilliant sunshine, or by cutting ditches to the sea and confining the water to definite channels. The same type of work when practiced on high inland plateaus increases the malaria rate, for here the transmiting mosquito is *Anopheles maculatus*. *Maculatus* does not breed in the shade and prefers the quiet edges of trickling streams. In the tea-garden section of India, particularly in Assam, the principal vector of malaria is *Anopheles minimus*. Its production can be controlled by shading the trickling streams and rills of the gentle slopes with the dense shade of duranta or other growth. Production in roadside ditches in this area has been prevented by filling the ditches with small boulders and large pebbles which, offering no impediment to the gentle flow of water, completely shade out *minimus*. Such measures would have no

effect in central and southern India where *Anopheles stephensi* is frequently found. This mosquito has been known to produce at the grassy edges of still ponds in shaded as well as cleared ditches. It will breed in almost any type of well or cistern. It has been found in quantity in the cool, lightless wells dug in the basement of large office buildings in Bombay, and at the same time has been taken from cast iron storage tanks on the roofs, wherein the water was uncomfortably hot.

Malaria epidemics which will visit portions of the Punjab in the autumn can be predicted in the spring. Prolongation of the annual spring flood prevents maturing of the grain crops but increases the mosquito crop. The resultant famine reduces human resistance so much that endemic malaria becomes epidemic. Drought may produce the same result, as was the case in Ceylon. Two years of partial drought so reduced the food supply as to produce a partial famine. At the same time it dried the streams to the point of pooling. Pools in the stream bed permitted breeding of excessive quantities of *A. culicifacies*. This excellent vector in a population made highly susceptible by famine caused a notable epidemic of malaria.

It is manifestly impossible in a single paper to follow the epidemiology of malaria as influenced by such diverse habits among the numerous mosquito species in all parts of the world. It is of interest here to interpret the ebb and flow of the disease in our own country in the light of the habits of *A. quadrimaculatus*, which is the only vector of the disease in the southeastern states where malaria is prevalent.

The endemic malarious area of these states is roughly bounded on the north by a line from northern Virginia to St. Louis, Mo., and on the west from this point to San Antonio, Tex. There are three other circumscribed endemic regions, namely the Rio Grande valley in New Mexico, portions of the Sacramento and San Joaquin valleys of California, and a tiny area in the Willamet valley of Oregon.

Although some species have very limited distribution, there are in our malarious areas nine species of *Anopheles: A. barberi, atropos, crucians, albimanus, maculipennis, pseudopunctipennis, punctipennis, walkeri* and *quadrimaculatus*.

The breeding or biting habits of these mosquitoes determine their efficiency as natural vectors of malaria. *Barberi* plays no rôle in the transmission of the disease, it being a rare mosquito, breeding only in water collected in tree holes; *atropos* is of no importance as it does not breed near man, being confined wholly to salt marsh areas of the Gulf and South Atlantic states; *crucians* is of little or no importance for two reasons: first, it seldom enters houses and, as *Anopheles* in general feed only at night, this mosquito has very little access to man, and second, because its breeding area is more or less restricted to unusual waters, such as waters with a high acid content, brackish waters and waters with much decayed vegetation; *albimanus*, although a good vector, is of little interest to us as it occurs only on the Texas-Mexican border; *maculpennis* is a good vector of malaria but occurs in sufficient quantities only in New Mexico, California and Oregon, where the malarious areas are com-

paratively small; *pseudopunctipennis*, although found in west Texas and in the Pecos valley of New Mexico, does not transmit malaria in our country; *punctipennis*, although capable of transmiting the disease and occurring in considerable quantities in all parts of the United States is wholly an outdoor biter and enters houses only in the late fall and then apparently for the purpose of hibernation. The place of *walkeri* as a malaria vector is in some doubt. Until two years ago it was considered a very rare mosquito. It was found breeding in only a few places in the grassy edges of swamps. So few specimens were encountered that it was assumed to be too rare a mosquito to play any part in disease transmission. With later-day use of the light trap with its suction apparatus, *walkeri* has been found in some sections to be present in considerable numbers. Observations in the year past have shown that it enters houses freely at night, feeds on human beings, and then disappears to unknown day-time roosting places. No outbreaks of malaria have yet been found ascribable to this species of *Anopheles*. *A. quadrimaculatus* is the chief vector of malaria in the greater portion of our malarious section. It breeds almost wholly in still water that is relatively clean. It requires some sunshine, never being found in dense shade. However, it requires some darkness, never being found in waters which are wholly unshaded, unless they have a type of flotage which casts narrow strips of shade where the mosquito larvae may lie during a portion of the daylight hours. Although *quadrimaculatus* will feed on animals, as does *punctipennis*, it will also feed voraciously on human beings and frequents human habitations. An ideal breeding place for *quadrimaculatus* is in freshly impounded water which floods a basin containing some underbrush and which is sparsely covered with trees. Such a body of water quickly gathers flotage of dead and dying land vegetation, twigs and leaves, among which alga soon appears. Such flotage not only offers the requisite amount of shade, but an abundant food supply. Such an impounding will not acquire a large quantity of natural enemies, such as top minnows and aquatic insects, for a number of years and seldom acquires enough entirely to prevent production of the mosquito.

The normal detritus passing down a narrow stream will clog the interstices of a fallen tree or branch and create a dam. These natural impounded waters are excellent breeding places for *quadrimaculatus*. Swamps covered by a growth of virgin timber, on the other hand, are not good breeding places. Such swamps are almost invariably covered with such a dense timber growth that sunlight can reach the surface of the water only in those small areas where an opening has been made by the fall of a dead tree. Swamps of this description have a small seeding of *quadrimaculatus*, but not enough to propagate malaria. When the lumberman enters, cutting out the large trees, leaving the small ones, the branches and the tree tops, he changes a safe water surface into one almost ideal for *quadrimaculatus* production. He has let in the sunshine without removing all of the shade, and he has left behind waste which not only creates fine flotage, but large portions of which tend to clog the channel which traverses the average swamp, thus making a series of ponds.

Agriculture, on the other hand, usually has the reverse effect. Good farming usually goes hand in hand with good drainage. Where land is at all valuable, *quadrimaculatus* swamps and ponds are drained. Drainage ditches may create *punctipennis* breeding areas, but as this mosquito plays no part in the transmission of malaria one can readily perceive the good effect of the extension of agricultural activities. Since early settlement days, lumbering and agricultural pursuits have gone along together, the one increasing the malarial hazard and the other reducing it. In some places, such as the bayou sections of the south, the lumbermen are still harvesting their crops of mosquitoes, whereas in the northern portion of the Mississippi valley the farmers are turning theirs under.

In light of the above-described habits of mosquitoes and man, it is interesting to speculate on the effect this mosquito has had and will have on the development of our country. In the fifteenth century all Europe was infected with malaria, heaviest along the Mediterranean. It is certain that Columbus brought a number of malaria carriers with him who infected the Caribbean area. Before 1500 there were devastating epidemics in Hispaniola (Haiti), which were later thought to be yellow fever and were offered as the principal evidence for the supposed American origin of yellow fever. The descriptions of these epidemics left behind by the Spanish priests show them to have been epidemics of estivo autumnal malaria in a highly susceptible, non-tolerant people. The Spaniards carried the malaria to Mexico and Central America, where *albimanus* spread the disease throughout the lowlands, and *pseudopunctipennis* carried it into the high plateaus. Why should *pseudopunctipennis* spread malaria in Mexico and Argentina and not in the Pecos valley of New Mexico and western Texas, where the density of *pseudopunctipennis* is high? The answer awaits the entomologist.

Malaria was not met by John Smith when he set up the first settlement in Jamestown, Va. However, it is probable that some members of his colony brought malaria with them. In any event, the disease was soon well established in Virginia from whence it spread up and down the middle Atlantic seaboard. Conditions for this spread were ideal on the Virginia peninsula, there being some natural swamps which were promptly lumbered for building purposes, and plenty of streams which were soon dammed to make mill ponds. Many of these ponds are there to this day, mostly preserved by fishing clubs. The malaria hazard was removed from them between 1922–1925, by placing baffle-boards at spillways to raise the water to a higher level during the winter and spring, in order to kill out the land vegetation. In the early summer the baffle-boards were removed, and the sudden fall of water stranded the flotage which had collected at the shores, thus leaving a clean, unshaded bank with no flotage. *Quadrimaculatus* did not appear in these ponds until quite late in the summer. I have no doubt that had the stream mill been available to the early Virginia settlers, and had they confined their lumbering operations to high ground, there would never have been any very great malaria problem in that state.

The Spaniards brought malaria to the southern Mississippi valley; *quadrimaculatus*, the early settlers and military expeditions carried it

throughout the Mississippi valley into the Dakotas on the west, and southern Canada on the north. The disease disappeared from the old northwest section, Canada, and the northern portion of the Mississippi valley long before 1912, which was the first year active malaria control efforts commenced in the United States. Extension of cultivated lands explains a good part of this recession. The largest, as well as the greatest number of farm drainage works have been completed in this section. In draining the farm lands, the majority of the *quadrimaculatus*-producing areas were removed. The great diminution in the number of mosquitoes, coupled with the short summer season, produced a sharp decline in the infection rate. When living conditions improved, the food supply became more varied than that which prevailed in pioneer days, and the population commenced to screen the homes, so that malaria disappeared. This large drainage-district area was not confined to the upper valley, but extended down the Mississippi well into the states which yet have high malaria rates. Although living conditions here also had become better, the combination of events which proved so successful in the more northern states was powerless to eradicate the disease. There are two probable reasons for this. First, as the delta region of the Mississippi is approached the quantity of standing water becomes greater, and second, in the south there is a very much longer mosquito breeding season, as well as higher temperatures, which allow the transmission of malaria to continue for one to two months longer than in the Great Lakes region.

Malaria entered the New England states in comparatively recent years with the commencement of industrial immigration from southern Europe. The disease disappeared soon after cessation of this immigration. This is easy to understand. New England was not a ponded, swampy region and it was not the habit of the early settlers to choose these few wet areas as proper village building sites. There was a moderate *Anopheles* population, not enough to create widespread epidemics nor enough to maintain endemic malaria, but a mosquito population large enough to produce some transmission of the disease when a large number of malaria carriers were constantly coming in from heavily infected countries.

The records left by early settlers and physicians in Georgia paint a picture wherein one may now see the inevitableness of the spread of malaria in that state. In early 1817–18, the City of Savannah was surrounded by rice fields which actually came into the edge of the town. Wet rice culture provides ideal *quadrimaculatus* breeding conditions. The malaria rate became excessive. The city fathers recognized the connection between wet rice culture and malaria, and enforced an ordinance prohibiting the wet culture of rice within a mile of the town. Curiously enough, we now know that a mile from its breeding place is the practical limit at which *quadrimaculatus* can spread malaria. Later the ordinance was not enforced and wet rice culture returned. So did malaria.

The settlement of Georgia moved slowly west from Savannah. Some of the old records state the conditions very clearly and remark "the settlers moved west with the axe and with the axe came agues, chills and fevers." One can visualize a group of settlers choosing their home

sites near a wooded lime sink or swamp. They carried cattle with them which needed watering, and they were not averse to being close to a water supply themselves. The best building lumber was to be found in the easily cut, straight cypress trees which grew in the swamps. It was natural to cut the trees in the edge of the swamp at places close to where the houses would be built, and which also would make good water places, easily protected, for the cattle. They let the sunlight into the densely shaded mosquito-free swamps and lime sinks, and created ideal breeding conditions for *quadrimaculatus*. These insects promptly picked up infection from the malaria carriers, and epidemics of the disease spread amongst the settlers. We are forced to the conclusion that malaria in the United States is almost wholly man made.

In 1912 the first concerted drive for malaria control in this country was commenced by the United States Public Health Service when it established a small division to carry on studies of the best methods for preventing the disease. There grew from this in state after state of the south separate divisions of malaria control within the state health departments. Before our entrance into the World War the Rockefeller foundation entered the field, aiding in the formation of malaria control divisions and carrying on control demonstrations in strategic parts of most of the southern states. Protection of the southern camps and their environs during the war furthered the advancement of malaria control. By the end of the war period it had become an integral part of the health work throughout the south. By 1930 there was practically no malaria left in the cities and larger towns of the south. The cities and large town had extended drainage operations well beyond the corporate limits. Methods of larvicide distribution, principally the dusting of Paris green, had provided a measure which the smaller towns and even villages could afford to practice. Malaria was left to the rural districts, which could not afford county-wide drainage and did not afford, except in rare instances, county-wide application of larvicides.

Screening campaigns commenced but the advent of good roads and cheap automobiles have curtailed the effectiveness of screening campaigns, for the average farmer no longer spends all of the nighttime within doors.

In 1933 the emergency relief agencies commenced to assign large numbers of those on relief to anti-malaria ditching in the 16 malarious southern states. This work is well in progress and to date there have been reported almost 25,000 miles of anti-malaria ditch. In spite of this, the malarious area of the south was as large in 1935 as it was in 1912 when the first work was done. This is not as discouraging as it might sound, nor was it a wholly unexpected occurrence. We know that malaria is not a static disease, but is subject to a cyclic rise and fall, each cycle in this country comprising approximately seven years. Following the general rise of 1928, it was not unreasonable to expect a similar rise in 1935. However, the rise was sharper and accompanied by a greater severity of the disease than was foreseen. This series of events added data in support of the theory which explains the cyclic rise and fall of the disease. There is some immunity conferred by malaria. As the rate rises the number of

people infected becomes larger and the mass immunity becomes greater, reaching its peak at the height of the disease. This immunity probably accounts for the subsequent subsidence of the disease. However, this immunity seems to wear out in a few years, and the population is then composed largely of non-immunes. This condition is conducive to a sudden expansion of the disease. With the extension of anti-malaria work the disease will decline more rapidly and the curve of the infection rate will reach lower and lower levels. The lower the level reached, the less immunity in the population and therefore the sharper the subsequent rise should be at the end of each seven year period.

Our falling malaria infection rates are accompanied by three definite phenomena. Epidemics disappear, the disease is less severe, and the endemic area not only moves southward but retreats from the higher and less moist areas of the southern states. On the other hand, whenever the cyclic rises occur in the infection rates, they are heralded by isolated epidemics, increase in severity of individual attacks, and a reinvasion of recently vacated territory. The extent of the rise can be relatively predicted by some of these changes. The peak of 1935–36 was forecast in 1934 by small epidemics in Ohio near Lake Erie, in Michigan, and in New Jersey, and by summer resort outbreaks in the mountains of Virginia and North Carolina, and by epidemic extension into north Georgia.

To prevent such epidemic rises in the future, three things are essential: The lumberman should drain the swamps where the trees are felled; the communities should maintain anti-malaria ditches which have been recently cut, and the engineer must stop leaving undrained borrow pits along his roads and levees, and he must protect his flood control and recreational ponds.

To extend complete malaria protection into the sparsely settled rural areas, it is essential that we find new methods of malaria control. Drainage methods are cheaper than they used to be but are not cheap enough. Dusting methods are cheaper, but they also are not cheap enough for rural use. Complete dependence cannot be placed on screening. Our greatest hope is in devising a biological method of controlling the production of *A. quadrimaculatus*. Only the gross biology of *Anopheles* is known. We do not know what constitute the minimal factors essential to *Anopheles* production. We do not yet know why some water areas which seem to be ideal never contain larvae of *A. quadrimaculatus*.

With the hope of answering some of these questions, the United States Public Health Service has recently set up a field laboratory at Savannah, Ga. The group working at this station comprises a physician, entomologists, a planktonologist, a physicist and an epidemiologist. They will carry on intimate studies of circumscribed areas over a number of years in the hope that they may find the essential weak links in the development of the mosquito—links which perhaps may be broken. The future of rural malaria control depends on a more accurate knowledge of the biology of the mosquito.—1-7-37.

Need for an Organized Research Program in Mosquito and Malaria Control

F. C. Bishopp, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

It is not only a great honor and pleasure to have Dr. Howard participate in this symposium but most fitting, since he is the father of medical entomology in this country and one of the world pioneers in the field.

We are indeed fortunate in having the head of the Malaria Division of the U. S. Public Health Service, one of the leading malariologists, to present this interesting and thought-stimulating paper. I have a feeling that perhaps our group needs most urgently this stirring message on malaria.

The foundation for mosquito and malaria control in this country was laid by an entomologist, none other than Dr. Howard. His interest in mosquitoes antedated the discovery that malaria is an insect-borne disease, for in 1896 he published a bulletin in which he dealt with mosquitoes as pests and demonstrated the practical use of kerosene as a mosquito larvicide. Soon after Ross's epoch-making discovery was announced, Dr. Howard published an account of the life history of *Anopheles quadrimaculatus*, and in 1901 appeared his book on mosquitoes which was to serve for several years as a "bible" for those interested in the control of mosquitoes. While he and other entomologists in this country have made noteworthy contributions to the entomology of malaria from time to time, this field of endeavor has not received from entomologists in general the attention it deserves. This fact has been brought out rather forcefully by Dr. Williams' discussion, which indicates that owing to the lack of a full understanding of the biology of *Anopheles quadrimaculatus*, malaria control in this country is not on an entirely satisfactory basis.

Out of the membership of some 1800 in these two great entomological societies, a mere handful—really less than a score—are giving any serious attention to a study of mosquitoes. In this I am not restricting the list to those working on *Anopheles* but am including those dealing with all mosquitoes, systematically, biologically and economically.

Our universities are casting about for suitable problems for graduate students, yet at their very doors lie dozens of important, interesting and readily available mosquito projects.

As indicated by Dr. Williams, *Anopheles pseudopunctipennis* is an important vector of malaria in Mexico and South America. Who knows but that the answer to the question as to why this species, abundant though it is in New Mexico and western Texas, does not trasmit malaria there, may be that the species has developed races with different host habits or other characteristics? The differentiation of the widely distributed malaria carrier *A. maculipennis* into 10 or more races, some of

which are important transmitters of malaria while others play no part whatever in the transfer of the disease, has given impetus to a more careful study of other anopheline species. It appears that certain of these races, which are rather easily distinguished in the egg as well as in the adult stages, feed largely on animals whereas others are house-inhabiting and bite man with avidity.

The amount of anopheline control work that has been accomplished with emergency funds during the last three years under Dr. Williams' capable direction can scarcely be visualized. I am sure Dr. Williams would be a most happy man if he knew that the vast drainage systems which have been installed during this period were of a permanent nature or would be fully maintained. It is easy for drainage outlets, if neglected, to become clogged and for pools to be formed suitable for the breeding of *Anopheles*. These newly formed pools, largely devoid of minnows and other mosquito enemies, may become prolific mosquito breeding places until drainage is reestablished or natural enemies have again reached maximum efficiency. And so the people must be taught that mosquito and malaria-free communities can only be realized at the price of intelligent and persistent effort. Carefully supervised maintenance work must be provided if full benefits are to be derived from this extensive emergency program.

The far-flung work in combating soil erosion, with all the benefits such a conservation program holds, carries with it a serious malaria menace if mosquito breeding is not given consideration. The thousands of newly formed ponds and lakes created in this work are fertile breeding grounds for *Anopheles*, and their control demands intelligent attention. Wildlife refuges, likewise, are likely to give opportunity for extensive breeding of *Anopheles*, and with it malaria, if such refuges are located in close proximity to human habitations.

On the other hand, mosquito control operations, when not adequately supervised, may adversely affect wildlife by altering the habitats of birds and animals. The interrelations of mosquitoes and other animal and plant life should be better understood, and mosquito control work should proceed with these complicated interrelations clearly in mind and with due regard for the conservation of wildlife and other natural resources.

The most effective fight on malaria can be made only with the fullest cooperation of many agencies. Well-organized and adequately financed local, county, state and national health units must take the lead in the drive to throw off this economic millstone. There is need for the active participation and cooperation of chemists, physiologists, botanists, pathologists, engineers, ichthyologists, ornithologists and entomologists in this campaign. Entomologists particularly should participate. Reference to man-made breeding places for *Anopheles* has been made by Dr. Williams. Breeding places of this kind are of the utmost importance in connection with malaria mosquitoes and give rise to serious trouble from other species. To prevent their occurrence the full cooperation of engineers in charge of power and irrigation projects, highway and railway construction and maintenance, and waterway improvements is essential. —1-18-37.

Myiasis of Man

W. E. Dove, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Different locations in which fly larvae occur in man suggest that for convenience the infestations may be classified as (1) penetrators of the skin, (2) accidental invaders of the intestinal and urinary tract, (3) larvae accidentally deposited in the eye, (4) scavengers of diseased tissues, and (5) parasitic invaders of injured tissues. The 47 species involved in myiasis as listed for the writer by D. G. Hall in a personal communication represent 10 families. Of these, 19 species are reported from man in North America. The following remarks refer principally to those species that attack man in the United States.

The present paper does not add new species to the list of larvae known to occur in man. It reports that the screw worm, *Cochliomyia americana* C. & P., may be expected in injured tissues of man when it occurs as a serious pest of domestic animals. It points out that control of screw worms in livestock also controls such infestations in man.

Penetrators of the skin.—Fly larvae capable of piercing the unbroken skin so as to gain ingress into the human body may be classified as (1) those which migrate within or beneath the skin and cause creeping diseases, and (2) those which remain at the original point of entry and cause nodular or pustular lesions.

Creeping Diseases.—A creeping disease often referred to in literature is due to newly hatched larvae of *Gasterophilus*, or the botflies of horses. The first case of such a disease with which *Gasterophilus* larvae were identified in North America was reported by Schalek of Nebraska in 1924. According to him the parasite tunneled very superficially through the epidermis of the forearm, causing a serpentine lesion. A living larva was removed from the burrow and was demonstrated on the tip of a scalpel. It was lent to the writer and was identified as *Gasterophilus haemorrhoidalis* (L). Schalek invited attention to the fact that the case occurred in an area devoted largely to the raising of horses and cattle, and that *Gasterophilus* adults were numerous. In 1926 Austmann reported the first case from Manitoba, Can. It occurred in a university graduate who was spending the holidays on his father's farm. The patient became aware of an itching spot on the medial side of his right elbow and within a day or two he noticed a red streak on the inner side of the forearm, which was associated with intermittent itchiness. About four weeks after the beginning of the trouble a larva was removed by Austmann and was identified by A. E. Cameron as *Gasterophilus intestinalis* (DeG.). In 1929 H. W. Miller, of Casselton, N. Dak., removed a larva from a serpiginous lesion on the left forearm of a farmer, about five days after the first evidence of migration in the skin. This larva was identified by F. C. Bishopp as *Gasterophilus haemorrhoidalis*. In 1933 another case of this affection of the skin was reported by Bedford, Williams & Newton (1933) from western Canada. The larva was removed surgically from the terminal of a linear lesion and was identified

as *Gasterophilus intestinalis*. All these cases occurred in the areas where *Gasterophilus* is known to parasitize horses and mules in considerable numbers.

Another creeping disease which differs from that caused by *Gasterophilus* is caused by newly hatched larvae of *Hypoderma*. In it the larva migrates beneath the skin in the connective tissues and appears as a traveling lump, but occasionally the deeper tissues are penetrated, giving rise to paralytic and other grave symptoms. In 1901 Topsant (Tamura 1921) recovered an organism which was identified by Brauchard as a second-stage larva of *Hypoderma lineatum* (DeVill.). It began its invasion on the lower part of the neck and passed over the right shoulder. It traveled a distance of about 64 centimeters and was extracted from a swelling about the size of a hazelnut, which was erythematous and painful.

In 1910 R. T. Miller reported a similar case in which the larva was identified as *Hypoderma lineatus*. The advancing end of the lesion was characterized by a small lump, which changed in position but in general had an upward course. Other cases of creeping disease in man in which larvae were identified as *Hypoderma* are reviewed by Bishopp, Laake, Brundrett & Wells (1926).

Invasions of the skin due to *Hypoderma* larva are easily differentiated from those caused by *Gasterophilus*. The former pursues a connective-tissue route, appears as a nodular lesion and is accompanied by pain, while the latter travels within the skin and produces itching sensations. The *Gasterophilus* lesions look like those known as creeping eruption. The histories of cases of the former invariably indicate associations with horses, whereas creeping eruption is always due to bodily contact with moist soil. In other papers it was demonstrated that creeping eruption (Dove 1932) is caused by infective larvae of the dog and cat hookworm, *Ancylostoma braziliense* deFaria. In this disease one is more likely to encounter a number of lesions, while in invasions of the skin by *Gasterophilus* multiple lesions are rare.

Nodular or Postular Lesions.—Larvae of two species of flies are capable of penetrating uninjured skin and by their presence producing nodular or purulent lesions which encapsulate the larvae. In 1919 such affections occurred in North America and were reported by Walker (1920), who described the larvae under the name *Wohlfahrtia vigil* (Walk.). In 1922 and 1931 Walker reported additional cases of this myiasis. In 1936 Ford reported four cases from the vicinity of Toronto, Can., and extended the studies made by Walker. All the infestations occurred in children who had been sleeping out-of-doors. Some of the lesions appeared like mosquito bites, except that each seemed to have a purulent center. This species shows a distinct preference for the necks of infant children and evidently maintains itself in newly born animals. According to Kingscote (1935) this species was obtained from the following young animals in the numbers indicated: mink 149, dog 20, cat 4, ferret 4, rabbit, 2, and fox 1. Kingscote says that in very small animals five to 25 larvae are sufficient to cause death, which usually occurs within about 10 days. Records of cases in children either north or east of the

Ohio river probably refer to this species. Those occurring in the western portion of the United States (Knowles 1925) are probably due to a closely related species, *W. meigeni* (Schin.).

In the Union of South Africa a type of myiasis comparable to that caused by *Wohlfahrtia* is due to the skin maggot of man, *Cordylobia anthropophaga* Grün. Fuller (1914) reports that infestations occur commonly in the scalp of very young babies, as well as in dogs, cats, horses, donkeys, camels and guinea pigs.

Fly larvae which penetrate the skin are macroscopic in size and cause visible reactions so that it is not difficult to determine their exact locations. If they are promptly removed, the injuries produced by them heal without diffiulty. Since these invasions represent the behavior of parasites in abnormal hosts they are unusually interesting to the medical profession and to biologists. This interest seems to warrant detailed studies on such subjects as the defense mechanism of the host, the effect of secretions of the larvae on the host, the fate of the parasites in abnormal hosts, and, in the case of *Wohlfahrtia*, the possible development of localized immunity. Since these parasites produce visible injuries so that detailed examinations may be made without sacrifice of the experimental animals, they afford a splendid opportunity for fundamental studies in the laboratory. As in the case of other parasites, the prevention of these infestations in man depends upon a reduction of the populations of parasites in normal hosts. Prevention of the occurrence of *Gastrophilus* and *Hypoderma* larvae in man depends upon control of these pests in horses and cattle.

Accidental invaders of intestinal and urinary tracts.—Fly larvae sent in from stool samples are often considered as causative organisms of intestinal myiasis. In many instances the statements accompanying the specimens suggest that the larvae caused injury to the intestines or that they were present with harmful organisms. More often they suggest contaminations in stool samples from outside sources, rather than the ingestion of larvae through the eating of uncooked or spoiled foods or from drinking unclean water. D. G. Hall, of the Division of Identification of the Bureau of Entomology and Plant Quarantine informs me that six families of Diptera are incriminated in cases of intestinal myiasis in North America, represented by *Eristalis tenax* (L.) in 19 cases, by *Piophila casei* (L.) in several cases, by *Drosophila funebris* (F.) in one case from Virginia, by *Hermetia illucens* (L.) in a case from Tennessee, one from Louisiana and one from Oklahoma, by *Muscina stabulans* (Fall.) in a case from New York, by *Sarcophaga haemorrhoidalis* (Fall.) in three cases from Florida and Missouri, by *Sarcophaga bullata* Park. in one case from Kansas, and by *Sarcophaga pallinervis* Thom. in three cases from Texas.

In 1933 Hoeppli & Watt found that some fly larvae were extremely resistant to urine, that they could live in empty intestines of freshly killed pigs for several days, and that they required only small amounts of oxygen. Apparently authentic cases of the occurrence of *Fannia canicularis* L. and *F. scalaris* F. in the genito-urinary tract of man have been reported in the United States. These observations suggest that

some fly larvae are capable of withstanding unusual exposure, and naturally cause physicians to ask what injuries might be expected as a result of the activity of fly larvae in the intestinal tracts of man. The question invites research workers to a most interesting field.

Accidental occurrences of larvae in the eye.—The nose botflies of sheep sometimes strike the faces of men and accidentally place larvae in their eyes. While the normal place for larviposition is in the nostrils of sheep, accidental infestations in the eyes of sheep herders are not unusual. Although the infestations are usually promptly removed before any serious injury is produced and cases are seldom reported, a few instances are on record in which the larvae have penetrated the eyeball and have caused blindness. Larvae from such cases in western Texas have been identified by E. W. Laake, F. C. Bishopp and R. Melvin as *Oestrus ovis* L.

Scavengers of diseased tissues.—Larvae found in necrotic tissues of wounds, including those in the natural openings of the body, may be usually regarded as saprophytic or beneficial larvae. They are represented in the Calliphoridae by *Lucilia sericata* (Meig.) and *Cochliomyia macellaria* (F.), and in Sarcophagidae by *Sarcophaga placida* Ald., a species occurring in Panama. In the present paper four case reports are given in which *Phormia regina* (Meig.), *Sarcophaga bullata* Park., and *Musca domestica* L. were identified.

At Soso, Miss., July 5, 1935, a white boy 4 years of age complained of having a fly in the ear. At night the fly was removed and on the following morning Dr. E. H. Williamson removed 15 to 20 small larvae. The fly was identified by Dr. J. M. Brennan as *Phormia regina* (Meig.).

At Blichton, Fla., during the latter part of February 1935, a negro man about 80 years of age had sores on his feet, which had been infested with fly larvae on several occasions. The little toe of the left foot and part of the great toe of the right foot were missing. Larvae were found on necrotic tissues between the toes of the right foot. Some of them were obtained and submitted to E. F. Knipling, who identified them as *Sarcophaga bullata* Park.

At Haynesville, Ala., August 24, 1935, six third-instar larvae were removed from an old sore on the leg of a negro woman. They were identified by E. F. Knipling as *Sarcophaga bullata*. Six second-instar larvae, also present, were recognized as *Sarcophaga* and were probably also *S. bullata*.

At Statenville, Ga., October 2, 1935, a mentally deficient negro woman, 45 years old, living in an unscreened shack at a turpentine camp had several sores on the legs. The sores were apparently of syphilitic origin and in a filthy condition. From one of them five larvae were removed and submitted to E. F. Knipling, who identified them as third-instar larvae of *Musca domestica* L.

Saphrophytic larvae in wounds are often helpful in disposing of decaying tissue and frequently result in prompt healing of stubborn infestations. If they are considered objectionable, the wounds should be so treated as to kill and remove the larvae without injuring the tissues, and suitable dressings should be applied for destruction of bacteria and for

healing. The saprophytic species of fly larvae that occur in the wounds of man are comparable to those occurring in animals. Their relative importance as scavengers and the effects of different maggot infestations on wounds of various types are some of the questions that beckon research workers.

Parasitic larvae or screwworms.[1]—Fifty-five cases of screwworms in man were reported during 1935 and authentic identification was made of *Cochliomyia americana* C. & P. in six instances. The identifications represent six localities in the southern states at a time when there was a high incidence of screwworms in livestock. Since laymen mentioned cases, in different localities, which were not treated by physicians, and described hemorrhages which are characteristic of screwworm injury, it is likely that more than 100 cases of screwworms in man occurred in the southern states during that year.

During 1936 only eight cases of screwworms were reported from all the southern states. In five instances the larvae were definitely identified as *Cochliomyia americana*. The reduction of cases in man during 1936 coincides with the reduction of screwworm cases in livestock for that year and is attributed to the screwworm control program.

Historical.—The earliest record of screwworms in man in the United States does not give an identification of specimens of the worms, but the evidence points strongly to the screwworm fly as the guilty insect. In his book "Indian Depredations in Texas," J. W. Wilbarger (1890) tells how his brother was shot through the neck by Indians, was stripped of clothing and scalped, and his wounds were later infested by maggots. This occurred about noon on an August day in 1833 about four miles from the present site of Austin, Tex. To quote from the published account:

> When Wilbarger recovered consciousness the evening was far advanced. . . . He dragged himself to a pool of water and lay down in it for an hour, when he became so chilled and numb that with difficulty he crawled out to dry land. Being warmed by the sun and exhausted by loss of blood, he fell into a profound sleep. When awakened, the blood had ceased to flow from the wound in his neck. . . . The green flies had blown his wounds while he slept, and the maggots were at work, which pained and gave him fresh alarm. . . . Night approached.

Since screwworm flies are attracted to fresh wounds and other blowflies prefer wounds with decaying flesh, and since the locality is one in which screwworm flies occur during the month of August, it seems reasonable to suppose that eggs were deposited on Mr. Wilbarger's wounds by screwworm flies.

Cases in Texas.—J. M. C., of Franklin, a farmer with chronic sinusitis, slept on a porch about noon on July 15, 1935. The following day he had a tickling sensation in his nose, which was followed by pain in the left sinus. He thought the pain was caused by a decayed tooth and had it pulled. The pain became more intense and at night one larva dropped from his nostril. During the following nine days a total of 385 larvae dropped from both nostrils. The case was treated by Dr. Wm. B. Kline,

[1] The writer is indebted to W. H. Clarke, R. A. Roberts, W. G. Bruce, T. F. McGehee and H. T. Rainwater for reports of cases which occurred during their activities on the screwworm control project.

of Bryan, who saturated cotton with chloroform and packed the nasal cavities for short periods. The patient suffered much pain, had hemorrhages from the nose, and was delirious several times during the week. Larvae obtained from this case were identified by H. T. Rainwater as *Cochliomyia americana*.

Other cases reported in Texas are as follows:

Clawson Community, Angelina county, child, nasal infection, occurred within the last five years; patient was not treated, died.

Angelina county, sawmill town, negro woman, vaginal infection, occurred about 10 years ago; died.

Rockland, Tyler county, young boy known as F. S's boy, nasal and eye infestations; treated in a hospital in Beaumont, handful of larvae removed from eye and nasal passages, recovered.

Cases in Alabama.—Sixteen cases reported from Alabama in 1935 are the following: June 18, Chilton county, one case, infected leg. June 29, one case, chronic ulcer. July 6, two cases, cancer and scalp wound. July 13, one case, infected finger. July 20, one case, cut on foot. July 27, one case, scratch. August 31, one case, scratch. September 7, one case, scratch. September 21, one case, cause unknown. October 5, one case, cut. October 19, one case, ear injury. November 2, one case, axe cut. November 9, one case, stubbed toenail. November 16, one case, scratch. November 23, Chilton county, one case, concer. November 23, Clay county, one case, nose infection resulting in death of child.

Cases in Georgia.—The first case of screwworms in Georgia was reported at Thomasville on July 7, 1934. It occurred in a cancer which involved most of the face and both eyes of a young man who had been confined to his bed for more than a year and a half, was totally blind and practically helpless. When he complained of new and severe pains, the local physician made an examination and found that screwworms filled a large cavity. They were closely wedged together with only their posterior ends exposed, a condition which is typical of the screwworm *Cochliomyia americana*. The infestation was treated, but larvae from the case were not submitted for identification. Before the patient died it was said that the odor of the wound attracted the screwworm flies to the screened window near his bed, and that they were constantly beating against the window in efforts to get to the wound.

At Lovejoy a colored male tenant farmer, age 22, with a sarcoma of the nose, experienced unusual pain on November 10 and 11, 1935. On November 12 some fly larvae dropped from his nose and on following days some larvae were removed. On November 16 the nose was treated with chloroform by Dr. E. H. Sellers, of the Georgia State Board of Health. Six larvae removed from the infested cancer were identified by H. T. Rainwater as *Cochliomyia americana*. Following treatment 10 third-instar larvae were taken on the night of November 16, and one on the morning of November 17.

The following 12 cases were reported from Georgia during 1935: July 6, Atkinson county, one man. July 13, Lanier county, two persons. July 20, Telfair county, one girl. August 17, Appling county, one man. August, Chatham county, one man had meningitis; case resulted in

death. August 31, Ben Hill county, one man. September 14, Richmond county, one man. September 28, Atkinson county, one man. October 19, Peach county, one man. October 19, Telfair county, one man. November 9, Thomas county, one man. November 16, Lee county, one man.

CASES IN FLORIDA.—At Moore Haven, on November 10, 1935, a man with a cancer involving the nose, forehead and a bilateral area beneath the eyes became infested with screwworms. He reported a burning, painful condition that had not existed before. Dr. E. R. Marlan observed a marginal redness with slight swelling locally, a small amount of hemorrhage over the denuded surface, and that the patient was restless, although he had a normal temperature. On November 11 the dressings were saturated with a sanguineous secretion and about half a dozen larvae one-fourth of an inch long were found. On November 12 the patient was given three-fourths of a grain of codeine hypodermically, and the blunt section of a tonsil needle was used to inject chloroform into the deepest portion of all cavities occupied by larvae. A compress of absorbent cotton saturated with 15 per cent chloroform in olive oil, warmed to about 105° F, was placed on the denuded area. This dressing was kept saturated by frequent spraying for 30 minutes. When removed the field was cleared of all larvae found and the treatment was repeated. Following the second treatment a fresh compress covered with cellophane was left in place for about 10 hours. For four or five days there was a rather heavy purulent discharge and some sloughing. As early as November 20 there was a healing tendency in nearly all pockets, less soreness in the entire field than for several months, and the patient complained less of pain. Between 175 and 200 larvae were removed at the time of treatment and during two days following treatment. The larvae were identified by E. F. Knipling as *Cochliomyia americana*.

N. McK., white, age about 70 years, lived alone about 14 miles north of Branford. In June 1935 she fell and was unable to move. When discovered several days later and placed in bed, Dr. P. C. Farnell found that screwworms had entered the vagina and were active in the sacral regions and navel. She was treated with chloroform and olive oil. It was estimated that about 1 quart of larvae were obtained from the wound. Treatment was given on June 14 and the woman died June 15, 1935.

J. G., negro, age about 30 years, was accidentally shot in the leg with buckshot during May 1935. The wound was treated a few days later by Drs. P. C. Farnell and I. P. Philpot, who removed about 100 screwworms. After treatment the wound healed.

Other cases occurring in Florida in 1935 are:

Young man, Orlando, cuts on big toes from trimming ingrowing toe nails became infested with larvae. Dr. J. L. Redding, Orlando, treated the case and one larva collected by him was identified by G. H. Bradley as *Cochliomyia americana*.

Mr. F., Monticello, bandaged sore on leg became infested with larvae; reported "almost a cupful" of larvae removed from wound.

White boy, Newberry, was holding a goat when a fly gained access to nose and remained for two or three minutes. A few days later Dr.

Philpot removed 163 larvae from the boy's nose and sinus. Some time later 45 additional larvae were removed. The boy recovered.

F. E. W., Blountstown, larvae in sore on leg.

J. L. W., Mascotte, larvae in cancer on back of neck.

L. L., Taylor county, larval infestation in old sore on leg.

Old man, Columbia county, two different infestations of larvae in cancer of face.

Mr. B., Pinemont, Suwannee county, larval infestation in armpit.

Man, Baker county, tore his shirt and skinned his shoulder. The injury was attacked by a screwworm fly while the man was sleeping during the noon hour.

J. B., age 3 years 6 months, Sanford, injured skin about size of dime resulting from fall off bicycle was treated at home, but failed to heal. Three or four days later a marked swelling, some discoloration, a hemorrhage and an odor were present. Dr. B. A. Burkes, of Winter Park, lanced the swelling, which was found to contain 10 or 12 larvae.

Negro man, St. John's county, was rudely awakened from his Sunday nap by the struggles of a fly in his nose. That night and during the following day he continued to sneeze. On Tuesday there was a bloody discharge from his nose and he complained of a severe headache and "little prickly feelings." On Friday the county agent and the doctor removed 25 larvae from the upper portion of his nose. Since the cheeks were swollen, they lanced on each side of the nose and 132 additional larvae were removed.

A. J., age 61, St. Augustine, felt an itching sensation in his nose on July 22, 1935. On the following day there was a bloody discharge from his nose. Dr. C. C. Grace reported a perforation of the nasal septum, which had a freshly denuded surface. One hundred nineteen larvae were removed and were identified by E. F. Knipling as *Cochliomyia americana*.

Lake county, a man pruning orange trees was scratched on the arm by a thorn. He reported that a screwworm fly oviposited in the fresh scratch.

Baker county, woman, screwworm infestation reported in cancer on face.

D. C., Lafayette county, fly oviposited in nose of patient during sleep. Case treated by Dr. Smith at Alachua county hospital.

V. E. McC., white, Palatka, one larva removed from mole on back of patient's neck by Dr. D. Y. Roseborough. Larva identified by H. T. Rainwater as *Cochliomyia americana*.

N. H., girl, age 10, St. Mark's, 15 larvae removed from "summer sores" on patient's legs.

During 1935, 21 infestations were reported from Florida to W. G. Bruce, supervisor of screwworm control in the state of Florida. In four instances, representing as many different cases, larvae were identified as *Cochliomyia americana*.

Cases in South Carolina.—S. D., colored, Cottageville, October 23, 1935, syphilitic sore infested with larvae. Treated by another negro with benzol and pine-tar oil with good results.

A child 1 year old, Anderson, November 10, 1935, infested in ear.

C. Z., colored baby, age 2 weeks, Calhoun county, June 1935, infested in navel and died.

B., farmer, age 72, Richburg, infested in nose. Had chronic catarrhal condition and slept in open during noon hour. Treated with benzol on cotton and larvae removed.

CASES DURING 1936.—L. H. B., negro mill hand, age 65, Valdosta, Ga., reported for treatment to Dr. J. M. Smith on October 26. About 18 larvae were removed from the nose and were identified by E. W. Laake as third-instar stages of *Cochliomyia americana*.

Negro man, 85 years old, Lake Butler, Fla., November 12; larvae removed from chronic sore on leg. Had several infestations during last two years. Larvae collected by W. L. Brown and identified by Dr. J. M. Brennan as the third instar of *Cochliomyia americana*.

Negro man, Alachua, Fla., May 6, larvae removed from nasal infestation by K. S. Littig were identified by J. M. Brennan as *Cochliomyia americana*.

Negro woman, Chuluota, Fla., July 13, larvae removed from cancerous wound near vulva were sent in and identified by J. M. Brennan as fully developed *Cochliomyia americana*.

CONTROL.—The 55 cases herein reported, together with unconfirmed reports received in the southeastern states, make it appear that more than 100 cases occurred in man during 1935. During 1936, when a high degree of control was obtained for screwworms in livestock, only eight cases were reported in man from all the southern states. The low incidence of cases for the present year is attributed to educational efforts which reduced the numbers of screwworms in domestic animals, and to some attention to the prevention of infestations in man, which also resulted from the educational work.

Since screwworms depend only upon the presence of screwworm flies and suitable injuries in living animals, the control work for livestock demanded the prevention of injuries which invite infestations and the prompt and proper treatment of infested wounds. The good methods of managing and growing herds, the timing of surgical work for the cooler months when flies are least active, and the control of Gulf Coast ticks, which predispose infestations, were stressed in practical demonstrations. As a result of the practice of these procedures by stockmen, gradual reductions were obtained in cases in livestock in the southeastern states during 1935 and further reductions during 1936. At the present time even greater reductions are being obtained from intensive educational and demonstrational work carried on in areas where the pest is active during the winter months.

In 1933 approximately 75,000 cases of screwworms developed in Georgia, and animals in about 20 counties in northern Florida became infested. In 1934 approximately 1,300,000 cases occurred in the southeastern states and necessitated an educational program for control of the pest. In 1935 there were only 228,660 cases and in 1936 there was less than 50,000 cases. These reductions were due partly to control methods carried on at the time of high incidence of infestations, and partly to coordination of the control efforts with natural advantages

gained from cold weather. The low atmospheric temperatures during the winter restricted the pest to areas below the 55° F isotherm, so that control work carried on in southern areas during the winter months greatly reduced the stock of parent flies in spring. By prompt treatment of animals during the spring, with special attention to cases in tick bites and navels of young animals, the pest was prevented from developing a big population, and there was more opportunity to keep it under control during the season of 1936. Stockmen delayed such surgical operations as earmarking, castrating and branding, and also prevented dog bites and other injuries and made prompt and proper treatment of cases, so that the pest was not permitted to increase its numbers greatly. Since treatments were given and wounds were prevented through efforts of the control program, and these accompanied gradual reductions in screwworm cases which cannot be accounted for in any other manner, it is concluded that the adoption of these treatments and fundamental practices through the educational campaign were responsible for the high degree of control in livestock and in man.

In addition to a reduction in numbers of cases, the control program manifests itself in a decreased death rate among infested animals. During 1934 approximately 12 per cent of all animals in the infested area of the southeast died of screwworms, or at the rate of 12,000 per 100,000 infested animals. In 1935 there was a mortality of 2.52 per cent, or at the rate of 2520 per 100,000 infested animals. In 1936 there was a mortality of only 322 deaths from 43,171 infestations in Florida, or at the rate of 770 deaths per 100,000 infested animals.

As indicated in this paper, the control work on screwworms did not take advantage of any particular habit of the insect or of any trick methods. It was based on fundamental practices which involved changes in old methods of handling and producing animals. It is believed that the control of screwworms is comparable to control methods for other insect pests, parasites, and diseases, in that the incidence depends upon what we learn and what we put into practice.

Summary.—(1) Larvae of *Phormia regina* and *Sarcophaga bullata* were found superficially on necrotic wounds, and housefly larvae, *Musca domestica*, were found in filthy injuries.

(2) *Cochliomyia americana* was identified when larvae were found deep in the tissues or in the nasal and sinus cavities.

(3) Where *Cochliomyia americana* was involved in nasal cases, intense pains were reported by the patients, and the infestations were accompanied by hemorrhages and swelling.

(4) In six instances of 55 cases reported in 1935 and in four instances of eight cases reported in 1936, fly larvae were collected and identified as the screwworm, *Cochliomyia americana*.

(5) In 1935 when there was a high incidence of screwworms in livestock, 55 cases were reported in man in the southeastern states. In 1936, when the incidence was low in livestock, only eight cases were reported from all the southern states.

(6) An extensive and intensive educational program involving practical demonstrations of treatment, prevention and methods of handling

and growing livestock furnished a sound and effective procedure for control of screwworms in livestock and man.

(7) Screwworms are like other insects, parasites and diseases in that effective control is dependent upon practical applications of fundamental knowledge of the pest.—1-18-37.

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Notes on Forms of Myiasis

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Since the discovery of the therapeutic properties of living fly larvae in diseased tissues, myiasis has lost some of its gruesomeness for those that were never infested, but those that have seen or experienced myiasis caused by an infestation of *Wohlfahrtia vigil*, *Cochliomyia americana* or *Chrysomyia bezziana* will still regard it as a malady to be abhorred. Myiasis of man is primarily a rural disease. It is by no means restricted to the lowly and uncivilized as is often depicted, for Dr. Dove has shown

that in any community there is a correlation between the number of animal and human cases. If animal myiasis is neglected in a stock-raising country, human myiasis will necessarily develop into a public health problem.

Intestinal myiasis also constitutes a problem, not because of its seriousness as a disease, but because so little is known about it. Fly larvae that are observed in human feces are often thought to have passed through the alimentary tract. Consequently numerous unnecessary examinations are made and the patients are unduly alarmed. The consensus of opinion among those that have studied the problem, however, is that the fly larvae in human feces are usually contaminants. Major Patton, after spending several years studying myiasis stated: "it is more than probable that the eggs of the Calliphorinae when ingested by man fail to hatch, and from the available experimental evidence it would appear that their larvae on being ingested fail to develop. On the other hand the larvae of some Diptera such as *Aphiochaeta*, *Fannia* and *Sarcophaga* are able to survive the action of the gastric juice and even reach maturity." Although the Sarcophaga larvae can survive the passage through the intestine, the majority of those found in feces perhaps were deposited there by the female fly. This is a very plausible explanation as many of these flies prefer to deposit their larvae in feces and since only a short visit is necessary, the fly often deposits the larvae unobserved. The problem is also complicated by the fact that larvae or eggs are sometimes deposited around the anus and gain entrance to the colon during defecation. In Siam where almost all of the inhabitants of the rural areas use open outdoor latrines, this form of myiasis is not uncommon. The latrine usually consists of a large pit several feet square and two to four feet deep with a coconut tree trunk laid across the top for support. The feces in the bottom of the pit are usually covered with flies and fly larvae. During the rainy season the pit becomes partially filled with water thereby preventing the flies from ovipositing. Those that use the latrine during this time find the flies very persistent in their efforts to deposit the eggs and larvae around the anus. Successful deposition undoubtedly explains the presence of many or most of the living larvae that are expelled from the alimentary tract. There are other infestations that are not so easily explained. For instance, there have been several cases of bladder myiasis reported without any explanation as to how the larvae may have reached the bladder.

I would like to report at this time a case of lung myiasis. Shortly after I arrived in Siam in 1932 I received from the Department of Public Health two small wormlike specimens that were so covered and filled with blood that they completely escaped recognition and the case history that accompanied them did not clarify the problem. In brief, it stated that the patient, a male 30 years old, complained of irritation in the throat and chest which produced severe coughing and hemorrhage. It was during one of these coughing spells that the specimens were expelled. Upon microscopic examination the larvae were found to be *Chrysomyia megacephala*.—1-14-37.

Some Therapeutic Uses of Insects and Their Products

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While it is true that insects as a class are far more harmful than beneficial, there are many species whose habits make them friends. We think at once, of course, of such well-known insects as honeybees, silkworms, plant pollinators and parasites of injurious species. But besides these, there are a few which play a part in the treatment of disease.

One of these is an ancient enemy now being made to serve as a benefactor. I refer to malarial mosquitoes, at present being used in the treatment of paresis or paralysis associated with syphilis and insanity. Mosquitoes which transmit malaria are no doubt among the world's most injurious insects, but their deadly habits are being adapted in this instance to serve a beneficial purpose.

Man has frequently had the skill to utilize dangerous or injurious things to suit his own ends. For instance, the venom from the moccasin snake is now used in the treatment of hemorrhage, the venom from the cobra to relieve the pain of cancer, and rattlesnake poison to reduce convulsions from epilepsy. This ability of man to turn the harmful into the beneficial probably deserves another illustration, again in the field of medicine. In Africa and South America certain plant extracts were formerly used by the natives on the tips of their arrows. These were powerful poisons and produced convulsions or paralysis when the victims were struck. Pharmacologists have taken these same poisons and have found in them two valuable drugs called veratrin and curara. These substances are useful in the treatment of certain conditions of the heart and nerves, and have a place in the United States Pharmacopoeia.

It is not surprising, therefore, that malarial mosquitoes, too, should be made to contribute something of value.

Malarial treatment of paresis.—Through casual observations that fewer cases of paresis appeared among those who had had malaria, there gradually developed the presumption that possibly the malarial organism had something to do with this matter. This led to artificial inoculation, in cases of paresis, with blood from persons having malaria. The first attempts were made in Europe in 1917, and favorable results were obtained. One objection to this method was, of course, the possibility of transmitting active syphilis organisms at the same time. About six years later one of the investigators got the clever idea of making the malarial mosquito serve as the inoculator, and again his experiment was successful. *Anopheles maculipennis* and *A. quadrimaculatus* are two species found to be satisfactory, and *Plasmodium vivax* is a suitable malarial organism. The mosquito, in biting the patient, injects *vivax* into the blood stream, which produces a fever and sets in motion certain reactions not yet well known.

The female mosquitoes are fed upon patients who have had tertian

malaria produced by *vivax*. After feeding, the females are placed in an incubator for about two weeks, until they become infectious. They are then ready for use, but if not needed at the time they can be kept in a refrigerator a little above freezing until required. Fortunately these mosquitoes go into hibernation readily in the refrigerator, and in fact they can survive the low temperature longer than the malarial organism within them.

It is not necessary to bring the patient to the mosquito in order to have him bitten. The mosquitoes infected with *vivax* are sent to the patient and allowed to feed on him. This transmits the organism, which then starts up a chain of events called malarial or fever therapy. To make malarial mosquitoes play a part in relieving a disease like paresis is surely turning the tables on the mosquito.

A technique has recently been developed which makes it unnecessary for the mosquito to bite the patient at all. The infected salivary glands are now being dissected and their contents injected into the blood stream. The gland contents remain potent for 26 days after dissection.

In regard to the results obtained, about 25 per cent of those given the malarial treatment are so much benefited that they can be restored to society; another 40 per cent appear to be improved and are made more tractable. This latter point is important, as such patients are more easily handled and able to take care of themselves. The remaining 35 per cent do not give indications of much, or any, improvement.

While electrical, chemical and other methods of producing fever for treating paresis have been tried, there appears to be no treatment or organism like the malarial *Plasmodium* to stimulate phagocytic reactions in the body. This might be part of the secret why the malarial treatment is so effective.

Bee-venom treatment of arthritis.—We are turning now from the consideration of a deadly insect and shall discuss briefly the use in medicine of a species which has long been classed as beneficial, the honeybee. In the history of man's long association with bees, stories have appeared in folklore and in other writings, that beekeepers are less troubled with arthritis than people in other occupations. For centuries this was disregarded, or at any rate it failed to awaken enough interest to start an investigation of the matter.

Details are meager regarding the gradual development of interest in this peculiar subject. Apparently the earliest attempts to use bee venom in the treatment of arthritis consisted in forcing bees to sting the victim repeatedly on the affected parts. Hundreds of stings appeared to be necessary to bring about any noticeable improvement, and the treatment was naturally very painful. The results of this crude method of treatment appeared favorable enough, however, to stimulate further curiosity in the treatment and further experimentation.

The next step taken was a logical one. Poison sacs were dissected in large numbers from bees, and specified quantities of the venom were injected with a hypodermic needle.

Thus, a small industry arose in Germany a few years ago around this treatment. It consisted of breeding bees for their venom. Women, suit-

ably protected with nets, sat in rows in front of the beehives. They caused the bees to sting into some sort of material which held the stings and poison sacs. The sacs were then collected and the venom extracted. Doses containing a certain quantity of venom in solution were prepared and were injected into the affected parts of the body.

This was a more scientific technique than allowing bees to sting the body, but it was still very painful. It seemed, however, to be sufficiently interesting to warrant further study and effort.

This was followed by another method, namely, of mixing the venom with an ointment and applying it to the skin where needed. This is one of the methods at present in use. In England there are at least two concerns now preparing bee venom in an ointment. It is sold in tubes like toothpaste and in two strengths, medium and strong. The tubes are marked on the outside into a number of sections, one for each day, and the treatment consists of squeezing out the required dose, placing it on a piece of cork which comes with the tube and rubbing this daily into the skin.

The British Medical Journal has regularly carried advertisements of the two English products, and from this it may be assumed that these ointments are at least harmless. The treatment has also reached the United States. With their customary readiness to try new things, Americans are now experimenting with the bee-venom treatment. One apiculturist is supplying a drug-manufacturing company with bee stings at the rate of $25 per thousand. The venom is mixed with a suitable carrier and taken by mouth.

No definite and reliable information appears to be available as to the therapeutic value of this treatment. Apparently its status here in the United States as a therapeutic material is not established, and I have heard of one lot of bee-venom preparation produced in England being seized at the border by federal authorities on the ground of fraudulent therapeutic claims.

Blister beetle extract.—Probably one of the best-known examples of insects used in medicine is that of the blister beetle or "Spanish fly." The juice is extracted from the crushed bodies of certain blister beetles of the family Meloidae. The extract contains a substance called cantharidin, and when the extract is applied to the skin it causes severe smarting followed by painful blisters.

This treatment arose from a practice of great antiquity in medicine. It was the peculiar custom many years ago to apply irritation to the skin in the treatment of internal diseases. The belief was that the disease could be drawn from the deeper organs to the surface by irritation of the skin. A later theory was that the beneficial results of this treatment were obtained by withdrawing liquid from the diseased organs to the skin and thus relieving congestion. This theory has been held until comparatively recent times. Actually it has been found that irritation of the skin does relieve pain and congestion in some instances. The practice of treating internal organs by external or counter-irritation still persists.

Cantharidin is one of the many substances used for that purpose. This drug is listed officially in both the United States and British pharmaco-

pociae and the dosage is stated. It has been used mostly as a counter-irritant on the skin and is applied in the form of a plaster. To obtain the desired effect the plaster is kept on the skin for about eight to ten hours.

"Spanish fly," as it is commonly known, has also been given internally, in some cases, to stimulate the kidneys and the reproductive organs. It will, however, cause the same irritating effects along the alimentary tract as on the skin. It can produce blisters and inflammation of the mouth sufficient to prevent swallowing. The tendency of cantharidin to cause nephritis, a disease of the kidneys, also makes it a dangerous drug to use.

Maggot therapy of nonhealing wounds.—We now come to a recent therapeutic use of insects which seems to have aroused a vast amount of interest among both the medical profession and the laity. I refer to the use of blowfly maggots in the treatment of chronic nonhealing and discharging wounds. This is a case of actually rearing maggots for the purpose of placing them in wounds to stimulate healing. It is only seven years since the first published report of this treatment was made, but in that time it seems to have reached the ears of everybody, doctors and laity alike. The interest is probably due both to the remarkable healing effects obtained and to the novel and repugnant nature of the treatment.

In popular accounts of the medical use of maggots, we are usually taken back to the time of the World War when soldiers brought in with wounds infested with maggots were found to heal more rapidly than those with clean wounds. This of course is true and it is also a fact that observations of the remarkable healing of wounds which had become infested with maggots had previously been made from time to time during the last 300 years. The real beginning of the maggot treatment, however, was made only nine years ago. At that time a Baltimore surgeon had two small girls in his hospital school who were suffering from osteomyelitis, a common infection which results in decay of the bones. These children had not responded to the usual treatments of this disease. They had been given every possible care without benefit and they were in a critical condition. Their doctor, remembering his experience with the beneficial results obtained through maggots in wounds of soldiers in France, resolved on a desperate attempt to save the lives of these two children. To use his own expression, he "took the bull by the horns" and secured some maggots from a piece of infested meat and actually placed the maggots in the wounds of these children, with a great deal of fear and misgiving. He repeated this twice a week for about two weeks. Both doctors and nurses watched these cases carefully. They found that the maggots were not at all harmful and, to their delight, the attendants noticed that the maggots were causing the wounds to heal. Treatments were then continued and finally resulted in complete healing. These two recoveries were so spectacular that the doctors of the hospital decided to apply the treatment to other resistant cases. A regular supply of maggots being necessary, a laboratory, the first of its kind, was started in Baltimore with the aid of the Bureau of Entomology, and their unique purpose was the rearing of sterile maggots for use in human wounds. The species of blowflies eventually found to be satisfactory were *Lucilia sericata* and *Phormia regina*.

The maggot treatment was next used in various other chronic wounds with similar excellent results. The following year an article was published in a medical journal telling the story of how maggots were able to heal wounds when other methods had failed. The news of such a novel treatment and the results obtained spread rapidly throughout the United States and into other countries. A number of surgeons went to Baltimore to learn directly how to rear maggots and how to use them. Hundreds of physicians began to try out the treatment and, for the most part, they obtained similar excellent results. Laboratories were established in hospitals to rear their own supplies of maggots. Two drug-manufacturing companies began to rear sterile maggots commercially and to ship them packed next to ice to any part of the United States.

Briefly, the treatment consists of placing several hundred young, sterile maggots in the wound and covering them with screening or bandage gauze to prevent their escape. The maggots feed for about three days, when they become full grown. They are then washed out and a new lot put in. This may be continued for several weeks until healing is completed. Blowfly maggots feed upon the dead tissue and so remove it from the wound. They also feed upon the bacteria which cause the infection, and kill the bacteria in their alimentary tract. They are thus very effective scavengers and rapidly dispose of the dead material in a nonhealing wound. It is of special interest that, feeding as they do in the midst of necrotic tissue and bacterial infection, their intestines and their feces should be sterile. They seem indeed to be living antiseptics, as they were called in the first article published on the maggot treatment.

While many members of the medical profession took a considerable amount of interest in the maggot treatment, of course there were many who scoffed at the idea and regarded it as barbarous and disgusting, and who said that maggots could never do what was claimed for them. It is true that the maggot treatment is a troublesome one to apply and requires a great deal of a doctor's and nurse's time. Sometimes it is also rather painful to the patient. Furthermore, it is expensive in comparison with other methods, and there appears to be no way of avoiding the truth that it is a very repugnant treatment for human beings to submit to. On the other hand, there is little question of the effectiveness of the treatment.

Despite its disadvantages, the maggot treatment took hold and became known and used throughout all the states in the United States, in Canada, Mexico, Cuba, Brazil, most of the European countries, Africa, India and Australia.

To learn at first hand, if possible, what the doctors who were using the treatment thought of it, the Bureau of Entomology sent out a questionnaire three years ago to more than 900 doctors. In the response 91 per cent of the users reported favorable result, with such comments as: "The maggot treatment is the most rapid and excellent treatment I have ever used"; "Healing was obtained in chronic cases when other methods had failed"; "The maggots are more selective than my surgery."

Some of the diseases for which maggots have been used are osteomyelitis, diabetic and varicose ulcers, gangrene, infected burns, and

wounds with large amounts of necrotic material and resistant to healing.

One oral surgeon, in treating resistant cases of osteomyelitis of the jaw, introduced maggots by way of the mouth to the bones of the jaw. He constructed a sort of cage by means of sheet dental rubber on the inside of the jaw and got the maggots into the cage through a piece of glass tubing extending outside the mouth. Other ingenious devices have been employed for special conditions; and the treatment seemed to supply a long-felt need in securing healing where other methods had failed.

It is now seven years since the maggot treatment was first announced. Today, however, the status of the treatment is not so impressive. There is no question among those who have used the treatment of its effectiveness, but whereas four years ago probably 1000 physicians and surgeons were using this method in the United States alone, it is quesionable if there are 50 applying the treatment now. The reason is that, despite the remarkable effects obtained, the disadvantages of the treatment outweigh the advantages. The discontinuance of the maggot treatment became noticeable in the Bureau of Entomology and Plant Quarantine about two years ago; and even the commercial producers of surgical maggots have closed up that part of their plant for lack of orders. It looks like a gloomy picture, doesn't it, especially as the treatment was very effective and not at all harmful.

Extract from macerated maggots.—To overcome some of the disadvantages of live maggots in the wound, an effort was made about four years ago in the United States to substitute the juices from the crushed bodies of maggots. The watery mixture thus obtained was filtered and a weak antiseptic added to prevent putrefaction. The liquid was then applied to the wound on wet gauze dressings. This method appeared to be less repugnant and was very easy to apply. Unfortunately, however, it was still more expensive than live maggots.

To the surprise of many, the application of the crushed extract to discharging wounds had much the same healing effect as the maggots. This was confirmed by experiments in France, Spain and South America. The extract has a wider application than maggots, as it can be used where they could not. For instance, the extract has been used in the treatment of middle-ear infections and it has also been sprayed up in the nose with excellent results. One individual in the United States even obtained a patent two years ago for a method of preparing an extract. Something disagreeable or impractical about this method seemed to persist, however and it too has fallen into disuse.

ALLANTOIN.—While on the subject of maggot extracts I might mention to you something of what the Bureau of Entomology and Plant Quarantine is doing in a study of these extracts. The attempt was made about two years ago to isolate and identify whatever healing agents there are present in the natural excretions of maggots (not the crushed bodies). This investigation led to the finding of a substance called allantoin in the excretions. Clinical tests of the healing effects of this material were made by a number of physicians and surgeons in the United States, and their reports showed that allantoin produces results similar to those of

maggots. Allantoin is now being produced chemically and independent of maggots. It is used chiefly in a water solution, and the treatment consists of keeping the wound moistened with the solution. It can be applied on wet gauze dressings or, if the wound is deep or extensive, the solution can be irrigated on with a syringe.

Fortunately, in the two and a half years in which allantoin has been used clinically, no harmful effects have been found. The solution is also nonirritating, tasteless and odorless. The treatment is painless in itself and it appears in some cases to reduce pain which is present in the wound.

The effects produced by allantoin are observable after two or three days' treatment. The discharge is reduced and the odor becomes less objectionable. The wound looks cleaner, and pinkish granulation or healing tissue begins to develop.

The discovery of allantoin in maggot excretions and its healing characteristics has been given a considerable amount of publicity. This has already resulted in such a wide use of allantoin that it seems almost premature. It would be more desirable if this new drug had come into use more slowly. Then, if any objectionable or harmful features should develop later, its use could be discontinued without too much prominence having been given to the drug.

Following its identification in maggot excretions, allantoin sales began to mount and they are still going up. In 1935 only one company made allantoin, and it was then known as a rare chemical for laboratory purposes. Now six chemical or drug-manufacturing companies are producing it synthetically. It is being sold in powdered form, in solution, in capsules ready for dissolving, and mixed in an ointment for external use. Allantoin is also being produced in a vegetable jelly form in collapsible tubes like toothpaste for use like the ointment and also for treatment of fistulas and sinus infections. The latest innovation, just out, is allantoin colloidally dispersed in dry powdered okra for stomach ulcers. One of the oldest chemical-manufacturing companies in the United States is now producing synthetically enough allantoin to treat about 1000 cases a month.

As to how allantoin occurs in animals, it is a product of metabolism and results from the break-down of the cell nucleus. In man and the manlike monkeys this metabolism ends in uric acid. That is as far as we and the manlike apes can take it, and it is excreted in the urine as uric acid. Now it is an interesting thing that the lower animals have an enzyme, called uricase, which oxidizes uric acid down one step further; namely, to allantoin, a stable end product of metabolism. Man and the manlike apes lose out on this for some reason, by evolution or otherwise, a disadvantage possibly following our higher development. Allantoin also occurs abundantly in some plants. The synthetic production of allantoin is brought about simply by oxidizing uric acid with potassium permanganate. Uric acid is plentiful commercially.

As to the types of nonhealing wounds which have been treated with allantoin, they include infections of the eye, ear, nose and mouth, osteomyelitis of all parts of the body, infected heat burns and X-ray burns, varicose and diabetic ulcers, and certain skin conditions, such as eczema and athlete's foot.

UREA.—I do not want to prolong the discussion of the subject of maggot extracts, but there is one more maggot extract which I should like to mention briefly. The structural chemical formula of allantoin showed that a part of the molecule can be split off by hydrolysis to form the common metabolic substance called urea. Urea is, of course, the main chemical constituent of urine and it is present in maggot excretions. It was therefore suspected that this splitting off of urea might occur in the wound during the allantoin treatment and that the healing effects might be due partly to the action of urea. Accordingly, an investigation was conducted by the Bureau of Entomology and Plant Quarantine, in conjunction with a number of physicians and surgeons, to determine what healing effects, if any, urea might have. It was found that a plain 2 per cent water solution of urea has healing characteristics similar to those of allantoin and maggots.

Extensive tests of the urea treatment were then made, with the result that urea is now being used in the treatment of the same types of nonhealing wounds as allantoin. It is also being combined with ointments and jellies and is applied in the same way as allantoin. One advantage of urea over allantoin is that it is very much cheaper to use. Daily treatments with allantoin cost about 5 cents a day, but urea is in a class by itself, as it is manufactured by the hundreds of tons, and daily treatments can be given for 10 days at a cost of less than 1 cent.

While urea occurs naturally in the urine, it is also a manufactured product. Recently improved methods of preparing it utilize three common gases, namely, nitrogen, hydrogen and carbon dioxide. The nitrogen and hydrogen are combined to form ammonia, which is liquefied and in turn combined with carbon dioxide to form urea. The resulting crystals resemble snow and are used extensively in industry as well as in agriculture.

In ancient writings, and frequently in the folklore of various countries, there have appeared comments upon the healing effects of urine when applied to infections and discharging wounds which were resistant to healing. Such observations were found dating back beyond mediaeval times to the writings of Cato, 175 B.C., and records have been found dating back as far as the ancient Babylonians, about 800 B.C., which show that they also used urine in the treatment of wounds which they could not otherwise heal. It is not surprising, therefore, that maggots, excreting two such healing substances as allantoin and urea, should be so effective in the treatment of wounds.

The list of insects of value in medicine is a short one, but it will no doubt be extended from time to time. Some of the present therapeutic uses of insects were undreamed of 25 years ago. Here are two more for someone to work upon, mentioned in the third edition of Gould's Medical Dictionary: (1) Cochineal, the dried bodies of a species of scale insect, used mainly as a dyeing agent, but thought to be valuable in whooping cough; (2) *Blatta*, a genus of cockroaches. The powdered bodies of *B. orientalis* are a popular remedy for dropsy among the peasants of Russia.—1-18-37.

Scientific Approach in Insect-Therapy

Wm. A. Riley, *University of Minnesota, St. Paul*

It is no empty formality, but recognition of a debt which we all owe, which has led the speakers on this symposium to express the honor which we all feel in having as our chairman Dr. L. O. Howard. To him, more than to any other individual, is due the widespread interest in medical entomology in this country.

The subject of the therapeutic use of insects, which we have just heard so ably discussed, is one which is greeted with amusement by not only the layman but by most entomologists. One may well question why this should be the case in these days when there is once more a vogue of the use of almost any type of animal secretions in medical practice. It may well be that we shall see the old-time beliefs in the efficacy of insects in the treatment of disease revived and subjected to a much-needed critical examination.

It must not be assumed that this ancient usage of insects in medicine had no reasonable basis. Dr. J. T. Lloyd (1920) in his very interesting discussion suggests that the utilization of so many species during the Middle Ages was due to the religious tenets of that period, which sought to find a useful purpose for every living creature. This may have had its influence but more basic is the view of Netolitzky (1916), who pointed out that a driving motive of primitive man was the search for food. In this search he tested out every living plant or animal in his environment. Some of these he found edible, others were dangerously poisonous and still others exerted definite physiological effects. These last he added to his primitive materia medica and some of them have persisted in one form or another to the present. At least 30 species receive more or less recognition in this country today.

An interesting case of what seems to be a parallel and independent development along this line came to my attention some years ago. As is well known, the hard spherical oak galls, the so-called Aleppo galls, are used in Europe and elsewhere in the treatmentof diarrhoeas. Such virtue as they possess is apparently due to the large quantity of tannin which they contain. I was much interested to find that the Chippewa Indians use for the same purpose a wholly different type of gall occurring on the sumac, *Rhus glabra*. It is due to the attacks of an undetermined eriophyid mite, which causes the characteristically stunted heads and curling of the leaves of the sumac.

Utilization of induced malaria in the treatment of paresis has extended in a very few years to hospitals all over the world. A question which has arisen is that of whether released patients might not constitute foci for the infection of anophelines and, through them, of human beings. I find among medical men a widespread opinion that this is impossible because the sexual stage of the cycle is dropped out after repeated transmissions by direct injection of infective blood. There is some evidence that this may occur in certain strains but it is a rare phenomenon. It is worthy of note that the most frequently quoted work in support of the theory in

this country was defective in that the sexual stages were not recognized, though they were present in the very slides which were used as a basis for the report.

The theory that bee stings, or bee venom in various forms, are effective in the treatment of "rheumatism" or of various types of arthritis, is hoary with age, and yet I am unable to find any really critical and scientifically controlled experiments which justify the claims today current. In view of the intense medical interest and the active research on the causation and treatment of arthritis it is hardly to be expected that a remedy so available and so widely advertised would be ignored by those research workers most concerned in getting at the truth of the matter.

Not alone for arthritis have the virtues of bee venom been extolled. I have before me an excerpt from a homeopathic medical journal as recent as 1929, claiming marvellous results follow use of the tincture in paralysis of the legs and bladder. It is still recommended in cases of inflammation of subcutaneous structures, retention of urine, and in irritation of the skin.

A consideration of standard methods of preparation of the tincture, as well as similar tinctures of spider and tarantula venom will indicate how far the proponents of these remedies are from having a critical scientific basis for their beliefs. For instance, in the preparation of bee venom, hundreds of live bees are shaken in a container until they are thoroughly angry and, presumably, secreting poison freely. They are then covered with alcohol and allowed to stand until the "venom" is extracted. No account is taken of the other body proteids, the adhering pollen, or honey, or of the fact that the venom is coagulated by alcohol and hence the major portion would be filtered out in the course of preparing an alcoholic tincture.

Similarly, entire tarantulas, other spiders, bedbugs, and other insects are ground up and their "curative properties" are extracted by alcohol. Who knows just what the patient is getting?

In his own work of the past five years, Dr. Robinson has well epitomized the scientific approach to a problem of the therapeutic use of insects. If fly maggots are to be placed in the diseased tissues of man, a seemingly obvious precaution is that of insuring that pathogenic organisms are not introduced with them. The tragic results of failure to recognize that necessity had been manifested in early clinical work. The first task, then, was the perfecting of technique for rearing and maintaining sterile maggots, a phase to which he and his associates made notable contributions. In the meantime, other workers developed the procedure of using the crushed bodies of maggots, a technique comparable to that of crushing entire insects in the preparation of tinctures. Pushing his studies further, Dr. Robinson discovered that in this watery mixture there was present the drug allantoin, and that a watery solution of this substance seemed to possess all of the healing virtue of the living maggots or their crushed bodies. Not satisfied with this contribution, he apparently has narrowed the problem down to the action of urea, a derivative of the allantoin.

It is not every entomologist who can push the study of the therapeutic

use of insects as far into the realm of biochemistry as can Dr. Robinson and it is to be hoped that he will extend his work to other problems in this important and interesting field.—1-18-37.

Ticks of the United States in Relation to Disease in Man

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The study of ticks received but scant attention in this country prior to the famous work of Smith & Kilbourne on the transmission of Texas fever. Since then, however, interest has gradually increased until there is now an extensive literature dealing with the taxonomy and bionomics of North American ticks and their importance as parasites and as carriers of disease. Many notable contributions have been made by investigators representing numerous organizations and institutions, among which may be mentioned the federal Bureaus of Animal Industry, Entomology, and the Public Health Service, the University of Chicago, the Montana State Board of Entomology, Harvard Medical School, and the University of California. Other worth-while contributions have been made by individuals, particularly physicians and veterinarians, not connected with institutions. The scope of the information which has thus been accumulated is rather broad, however, and this paper is limited to the presentation of information of general significance relative to the tick-borne diseases of man in the United States and the ticks that are actually, potentially, or indirectly involved in their transmission.

The history of tick-borne diseases of man in this country began with the investigation of Rocky Mountain spotted fever in western Montana in 1902, and the classic studies of Dr. Howard T. Ricketts, which resulted in the demonstration of transmission by *Dermacentor andersoni* in 1906.

During the three decades that have since passed, four more diseases that are entirely or in part tick transmitted have been found to be endemic. Tick paralysis was described in 1912, tick transmission of tularaemia was reported in 1924, Colorado tick fever was belatedly acknowledged to be a disease entity in the late twenties and tick-borne relapsing fever was recognized in 1930.

For most of this period it was supposed that tick-borne diseases were confined to the Rocky mountain region, but with the recent discovery that spotted fever is prevalent in many of the eastern and central states, and that both relapsing fever and tick-transmitted tularaemia are present east of the Rockies, the problem is now recognized to be one of national concern. While perhaps not a major public health problem, it is nevertheless an important one. This importance is to be found less in morbidity and death rates than in the worry and fear to which the population of large areas of the country are annually subjected for several

[1] Contribution from the Rocky Mountain Laboratory, U. S. Public Health Service, Hamilton, Mont.

months. In the more severely affected sections this is found reflected in depreciated land values and the extent to which the full utilization of opportunities for recreational and outdoor life is being prevented. This is particularly true, and will continue to be so, in the Rocky mountain region and adjacent areas, where the character of the country and, in many sections, the type of development, are such as to foster, and in some instances to enhance the very conditions favorable for the natural maintenance and perpetuation of the ticks and disease agents concerned.

It may be well to state at this point that there are at present no practical methods applicable to large areas for the control of the ticks which transmit these diseases. Parasites, as thus far used, do not offer much promise, at least in the Rocky mountain region. Control on extremely small, highly localized areas is sometimes feasible under highly favorable conditions, but even so, there are many sections of the country in which the results attained will lack any consequential degree of permanency.

The information offered on the subject in hand is presented in three sections. The first contains significant data concerning each of 13 species of ticks involved, the second treats of the above five diseases and their transmission, while the third concerns other conditions that are known to be associated with tick bite or have been so reported. In the first section the ticks are divided into three groups—those proved to be agents of disease transmission, those considered as potential agents and those which are involved indirectly. Nine of these ticks are members of the family *Ixodidae*, four of the *Argasidae*. The former are all three-host species, *i.e.*, each successive stage (larva, nymph and adult) feeds on a new host animal. The argasids in addition may feed several times both as nymphs and adults. Also these several stages of the ticks of both groups are able to survive for long periods between feedings. Longevity and the use of new hosts by successive stages are significant factors in the actual or potential importance of these ticks as disease carriers.

DATA RELATING TO TICKS CONCERNED IN DISEASE TRANSMISSION

I. Ticks that are proved transmitters of causative agents of disease.—This group contains five species—*D. andersoni* Stiles, *D. variabilis* (Say), *D. occidentalis* Marx, *O. turicata* (Duges), and *O. hermsi* Wheeler.

The first, known popularly as the Rocky Mountain spotted fever tick, or Rocky Mountain wood tick, is our most versatile species as a disease vector. It transmits four disease agents.

D. andersoni is indigenous to the Rocky mountain region and adjacent areas. Due to rapid intensive spread during recent years, it is now prevalent in many intrarange areas in which it was unknown a few years ago. Extensive (that is, outward) spread also appears to have been definite, particularly eastward and westward, but much less rapid. To the east, *andersoni* is now present in the western portions of at least the northern west-central states and occurs occasionally in western Nebraska. In California and Oregon it was unknown except east of the divides of the Sierras and Cascades until the past few years. Recent reports, however, indicate its sporadic occurrence on the Pacific slope.

In 1934, we received specimens from Redding, Calif., and Herms and Wheeler reported (by correspondence) its occurrence in counties bordering San Francisco bay. In Oregon, reports and specimens received show its occurrence near Warren, Columbia county, and Corvallis, Benton county, both west of the Cascades. It extends northward into southern Canada and is reported from central British Columbia eastward at least into Alberta. Southward it extends into northern New Mexico and Arizona. Our southernmost record in California is from the vicinity of Bishop.

D. andersoni is most abundant in regions or localities where the predominating vegetation is low, brushy and more or less open, *i.e.*, in areas where there is good protection for the small mammalian hosts of the larvae and nymphs and sufficient forage to attract the large animal hosts, either wild or domestic, of the adult ticks. It is relatively quite scarce in heavily timbered areas or country of a strictly grassland, prairie type.

Several factors combine to make *andersoni* the most important of our native ticks as an agent of disease transmission. These are: (1) the larval, nymphal and adult ticks each feed on new host animals; (2) its host relationships are very broad, most of the western rodents and several species of carnivores serving as hosts of larval and nymphal stages, while the adult ticks engorge on numerous species of ungulates, among which most of our larger domestic animals are of great importance; (3) its range includes a portion of the United States, large in area, in which animal life is very abundant and likely to remain so for many years, and in most sections of which man's activities are such as to invite both intensive spread and increasing abundance; and (4) the adult tick is a very common parasite of man.

Dermacentor variabilis.—The American dog tick, eastern wood tick or eastern Rocky Mountain spotted fever tick, though not definitely incriminated as a disease vector until 1931, is the proved transmitting agent of two diseases.

It is generally distributed from the Atlantic coast to the Rocky mountains, although in some sections (the greater portion of the New England states, for example) it is relatively scarce. It is present in some parts of eastern Montana and there are scattering records of occurrence in Colorado, New Mexico, and Arizona. Farther west, it again becomes relatively numerous in parts of California. It has also been reported in southern Oregon, but we have thus far been unable to verify this in spite of extensive collecting activities. It is present in southern Canada, eastward from Saskatchewan.

D. variabilis has not attracted much attention until the past five years, and there is little evidence to show whether its range has decreased or extended. If, however, Hooker, Bishopp & Wood's map of 1912 gives the correct distribution for that period, the above-recited range indicates a definite westward spread in the northern west-central states.

In contradistinction to *andersoni*, it is far more common in wooded and brushy areas.

As an agent of disease transmission to man, it is of considerable importance, but does not rank with *andersoni*. As in the case of the latter, all

three stages feed on separate hosts, but the variety of host animals is apparently much more restricted. The dog is the best-known host of the adult stage, but adults also occur to a considerable extent on the larger domestic animals, on deer, and at least occasionally on some of the larger species of rodents. They attach to man with the same readiness as do those of *andersoni*. The hosts of the immature stages are less well known, but mice of the genus *Microtus* are important and probably some species of *Peromyscus*.

Dermacentor occidentalis.—The Pacific coast tick has been studied much less as a disease vector than the two preceding species. Although there is no proved instance of infection in man caused by this tick, it is included in the group of proved vectors because of convincing circumstantial evidence.

This *Dermacentor* is abundant in many parts of California, particularly in the western portion, and in southwestern Oregon. Its range includes, and apparently exceeds, the California range of *variabilis;* in northeastern California it perhaps overlaps that of *andersoni*. It has been erroneously reported from various points in the Rocky mountain region and farther east.

There is no authoritative information as to whether this tick is extending its range, although certain data suggest a slow northward spread. It has increased greatly in abundance in some sections, notably southwestern Oregon.

There has been but little information on the life history, habits and host relationships of *occidentalis*. These have been studied during the last two seasons by Kohls (1937), of the Rocky Mountain Laboratory. The host relationships of the adult ticks are essentially the same as those of *andersoni*, its closest relative. The larvae and nymphs also seem to have the same broad host relationships as the latter tick, but the number of host species is less because of the more restricted range of the tick. According to unpublished observations by Kohls, it sometimes, at least, aestivates or hibernates on vegetation.

Ornithodoros hermsi.—The bionomics of this recently described tick have been studied by Herms and Wheeler. It transmits but one disease.

It occurs at altitudes above 5000 feet in the San Bernardino mountains of southern California and the Sierra Nevada mountains of east-central California and west-central Nevada. The only other known record is from the Moscow mountains of northern Idaho, over 500 miles northeastward. However, we have evidence that suggests its presence in the high, wooded, mountainous portions of Arizona and it likely occurs in other mountainous sections west of the continental divide.

The data collected by Herms & Wheeler (1935) indicate that the various stages of *hermsi* normally feed on small rodents such as chipmunks and tamarack squirrels. Log cabins and other poorly constructed types of dwelling, such as are frequently found in mountainous country, may become infested with this tick, since they are often frequented by small rodents, particularly chipmunks. These and other small mammals may even have their nests in the walls or under the floors.

Ornithodoros turicata.—This species is common in localized areas in

many parts of Texas and has been reported from New Mexico, Arizona, California and Florida. This past summer it was found by us to be abundant as far north as Clarke county in southwestern Kansas. In Texas it is often present in great numbers in caves. Like *hermsi*, it transmits but one disease.

The information available suggests that it attaches readily to a great variety of hosts. In Kansas this year Davis found it numerous in rodent and terrapin burrows and collected it from spermophiles, cottontail rabbits, prairie dogs, prairie dog owls, jackrabbits and terrapins. It was abundant in all stages on terrapins, and in the sand of a burrow containing 11 terrapins it was estimated that there were 2000 specimens. We have also recently collected them at a zoological park in Bexar county, Tex., from terrapins and from sand in an enclosure occupied by a variety of snakes that evidently served as hosts. It has been reported also from cattle, horses and pigs. Banks (1909) records it from "gopher" holes and from a tortoise in Florida. Kemp (1936) has noted that it is found in "abandoned rock houses" in Texas. Its occurrence in dwellings is perhaps less common than that of *hermsi*.

II. Ticks that are potential transmitters of causative agents of disease.—There are also five species in this group—*Amblyomma americanum* (Linnaeus), *A. cajennense* (Fabricius), *Ornithodoros parkeri* Cooley, *O. talaje* (Guérin-Méneville) and *Ixodes ricinus californicus* Banks.

All these ticks bite man freely but none is a proved agent of disease transmission to human beings in this country. They are designated as potential transmitters because each species bites man and either has been found naturally infected with the etiological agent of one of the infections herein discussed or it has been shown experimentally that one of these disease agents will survive in the tick species in question and can be transmitted by it and that the tick frequents hosts from which this infectious agent could be ingested. One species, at least, is the known transmitter in another country of a disease that is prevalent in this country.

Amblyomma americanum.—The lone star tick is a potential carrier of two disease agents. It is widely distributed in southeastern and especially south-central United States and has been reported as far north as Labrador and Manitoba, and as far south as Argentina. In this country, it is abundant in only the southern part of its range. There is no evidence to suggest it is spreading into new areas; in fact, it is likely much less abundant than formerly in northern United States. The reported hosts include most domestic animals, many carnivores and certain rodents and birds. The larval and adult stages, at least, frequently infest man.

Amblyomma cajennense.—This species also is a potential carrier of two diseases. It is abundant in the southern tip of Texas and is possibly present in the Biscayne bay region of southern Florida and perhaps in the very southern portion of California. It is common in Mexico, Central America and in South America south to Argentina.

We know of no evidence indicating any tendency of this tick to enlarge its range in the United States. It infests a large variety of hosts, including domestic animals, carnivores and rodents. It is a serious pest of man and bites freely even in the immature stages.

Ornithodoros parkeri.—This tick, recently described by Cooley (1936), is a possible vector of one disease. It has been collected by staff members of the Rocky Mountain Laboratory as follows: in 1934 on Poison Spider creek, near Casper, Wyo., from ground squirrels, a jack rabbit and a prairie dog, and from a cottontail rabbit near Yakima, Wash.; in 1935 in large numbers from ground squirrel burrows on Poison Spider creek; and in 1936, incident to field studies on sylvatic plague near Dillon, Mont., it was repeatedly taken from the burrows and nests of the Richardson ground squirrel. Later in 1936, immature stages, apparently of this species, were collected from two species of ground squirrels in Washington and Wayne counties, Utah, by field crews of the Public Health Service Plague Laboratory at San Francisco.

Ornithodoros talaje.—"The talaje" is a recognized agent of disease transmission in South and Central America, but has not been known as such in the United States.

It has been reported from Florida, Texas, Arizona, Southern California and Nevada. It is supposed to infest both small and large mammals. In Arizona we have found it infesting kangaroo rats and their burrows (Kohls & Cooley 1936). This is believed to be the first native host record in the United States. It bites man and infests dwellings. Matheson (1931), Herrick (1935) and Riley (1935) have reported 10 instances of its occurrence in residences in New York, Wisconsin and Minnesota, respectively. Such infestations are likely due to the importation of ticks in shipment of materials.

Ixodes ricinus californicus.—Until recently there have been but few published data concerning this tick. The Rocky Mountain Laboratory, however, during the past few years has accumulated a number of locality and host records (Kohls & Cooley 1937). It apparently occurs more or less continuously in a strip of country bordering the entire west coast of the United States and extends northward beyond Vancouver, B. C. It is abundant in many local areas. Our most eastern record, and the only one from the Sierras, is from Bass lake, Madera county, California. We have but few records from northwestern Oregon and only one from Washington (Orcas island). The adult ticks infest dogs, horses, cattle, deer, cats, cougars, coyotes, jack and brush rabbits, and frequently attach to man. The larval and nymphal ticks have been collected from jack rabbits, mice, Douglas ground squirrels, once from a dog, and are present very commonly on lizards (recorded from four species) to which they usually attach in the lateral cervical pouches (Jellison 1934). It is possible that lizards are the more important larval and nymphal hosts. It is a suspected vector of one disease.

III. Ticks indirectly concerned in occurrence of specific infection in man.—This third group contains three species—*Haemaphysalis leporispalustris* (Packard), *Rhipicephalus sanguineus* Latreille and *D. parumapertus* Neumann. None bites man except rarely, with the possible exception of *R. sanguineus*, but each is an actual or possible indirect agent of human infection because of its known or probable importance as a factor in the natural maintenance of one or more of the tick-borne diseases herein discussed.

Haemaphysalis leporis-palustris.—The rabbit tick is the most important of this group and is a definite factor in the natural maintenance of two diseases. It occurs throughout the United States and extends south through Mexico and Central America at least as far as Brazil. Northward it occurs in Canada to perhaps the fiftieth parallel, and also in southern Alaska.

It infests numerous varieties of rabbits, hares and of ground-frequenting birds. Its most important hosts are snowshoe hares, cottontail rabbits and ruffed grouse. On the first, in particular, it may occur in enormous numbers, often many thousand on a single animal, and the presence of several hundred, sometimes thousands, on one bird is not uncommon.

It is possible that some of its bird hosts may act as agents in its intensive spread.

Rhipicephalus sanguineus.—The brown dog tick is the possible carrier in nature of two diseases. It is widely distributed in tropical and subtropical countries and is found in some sections of the temperate zones. It was probably introduced into this country, and in 1912 it was recorded only in the southern tip of Texas. Though still most abundant in the south, it is now distributed sporadically throughout the southeastern and south-central states and we have unverified reports from islands off the southeast coast of Massachusetts. It has been collected as far north as Minneapolis, Minn. and as far west as Phoenix, Ariz. It is evident, therefore, that it is spreading more or less rapidly and it may sooner or later become more or less generally distributed over a considerable portion of the country. However, it remains to be seen whether it can really become permanently established in some of the sections from which it has been reported. Transportation by dogs, especially in automobiles, is likely an important factor in its spread.

The dog is the most important host, but it has also been reported from other domestic animals, and from birds and reptiles. In European countries the immature stages have been reported from rodents. In this country it apparently only occasionally bites man, but in certain other countries seems to do so rather frequently.

Dermacentor parumapertus.—This specific designation is used to include both *parumapertus* and the form heretofore known as *parumapertus marginatus.* Unreported studies by Cooley have shown no justifiable reasons for considering *marginatus* as a subspecies.

Parumapertus occurs from the Columbia river in eastern Oregon southward through California and southeastward to western Texas.

Rabbits, particularly the jack rabbits, are the most significant hosts. This tick rarely bites man and is the suspected carrier of but one disease.

DATA CONCERNING TICK-TRANSMITTED DISEASES

Rocky Mountain Spotted Fever.—Spotted fever is by far the most important of the diseases discussed. It is a rickettsial infection, attacking the lining of the peripheral blood vessels, the resulting lesions causing a characteristic rash. The case fatality rate is usually reasonably constant in any given locality or focus and varies from as low as 5 to as high as

82 per cent. In the east it approximates 20 per cent. The majority of infections occur in persons engaged in outdoor pursuits.

Spotted fever is most prevalent in the northern Rocky mountain region in eastern Oregon, Idaho, Montana and Wyoming and along the mid-Atlantic coast in an area extending through parts of Maryland, Virginia and North Carolina, and including the District of Columbia. It is present in all the Rocky mountain and Pacific coast states and in 27 of those of the central and eastern groups; it has been reported from 25 of the latter within the past six years. Though recognition of spotted fever east of the Rocky mountain region has been relatively recent, the fact that many widely scattered endemic areas have already been shown to exist in 27 of the 38 states east of the Rocky mountain region suggests, first a long-established endemicity, and second, that infection is widely distributed in nature and that this will continue to be reflected by case reports from new localities and likely from new states.

In some parts of the west spotted fever is increasing in prevalence, while in others, for reasons not fully understood, it is decreasing. There is also an unexplained tendency toward cyclic prevalence, both regionally and locally (Parker 1935).

In the *D. andersoni* range cases usually occur during the spring and early summer, most of them during April and May, but there are occasional fall and winter cases. In the *D. variabilis* range, cases occur during the late spring and summer in accordance with the later seasonal occurrence of the vector.

The virus is normally transmitted by the tick bite, but infection occasionally takes place through the abraded or unabraded skin which has been contaminated with the highly infectious tick tissues. Tick excrement is also infectious, but much less so than tick-tissue virus and, unlike the latter, will not infect through unabraded skin.

There are two proved and four potential tick carriers of spotted fever to man, and one proved and one potential carrier in nature. The two proved carriers to man are *D. andersoni* and *D. variabilis*. Their combined ranges cover all but a relatively small portion of the United States and there is promise of still further inroads by both species into the areas now unoccupied; also, in the case of the former tick, at least, an increasingly intensive intrarange distribution. The latter is more closely associated with the home through the agency of dogs, with the result that in *variabilis* territory there is a higher proportion of cases in women and children. These ticks, of course, also play an important rôle in the natural maintenance of the virus. They can function in three ways: (1) by transmitting infection to susceptible small animal hosts from which normal ticks may in turn acquire the virus, (2) by generation-to-generation transmission of the virus through the egg, and, (3) in *D. andersoni* at least, we have shown that noninfected females may be infected by virus-carrying males during the act of impregnation (Philip & Parker 1932).

The four potential carriers to man are *D. occidentalis*, *A. americanum*, *A. cajennense* and *R. sanguineus*. In all four, larva-to-nymph-to-adult-to-egg survival of spotted fever virus has been experimentally shown, and the active stages transmit infection readily. The geographic range of each

of these ticks is either included within, or overlapped by, that of one or the other of the two improved carriers, and furthermore each of them meets in common with either *D. andersoni* or *D. variabilis* on spotted fever susceptible hosts. It appears probable, therefore, that any one of these four species may be a present carrier of spotted fever or that it may become one.

The evidence as to whether or not *D. occidentalis* is a present carrier is inconclusive. Three cases have been reported from within the occidentalis range, two in California and one in southwestern Oregon. However, in spite of numerous tests, we have never recovered a proved strain of spotted fever virus from ticks of this species collected in nature.

In 1932 a case was reported from northeastern Missouri and *A. americanum* was indicated as the likely vector. Also, specimens of this species, collected that same year in Louisiana from premises where a case originated, produced in test guinea pigs a reaction suggestive, but not conclusive, of the presence of spotted fever virus.

A. cajennense is the presumed carrier in Brazil of São Paulo exanthematic typhus, a disease which, if not the same as spotted fever, at least differs from it only in minor points. Thus far there has been no evidence incriminating this tick as a carrier of spotted fever in this country, but its range in Texas lies within that of a proved carrier, *D. variabilis*, so that if not now infected, there is an ever-present likelihood that it may become so at any time through the medium of such spotted fever-susceptible hosts as young dogs, on which the two species meet in common.

R. sanguineus also shows potentialities. There is no evident reason why this tick should not be an efficient vector of spotted fever. In this country, however, it apparently so seldom bites man, that it is unlikely that it can become more than a minor factor in infecting man directly. In parts of the Old world it bites man more freely and is the carrier of boutonneuse fever, which some investigators considered to be only a variety of spotted fever.

There remain to be considered in connection with spotted fever the two ticks, *H. leporis-palustris* and *D. parumapertus*, known and potential transmitters, respectively, of spotted fever virus among rabbits in nature. The available epizootilogical data indicate that the rabbit tick may be an even more fundamental factor in the natural maintenance and perpetuation of spotted fever virus than either *D. andersoni* or *D. variabilis* (Parker 1928, 1935). In contradistinction to these two species, however, which may carry very mild as well as highly virulent strains of the virus, the rabbit tick has thus far been found carrying only strains of an avirulent type which seldom cause more than a low-grade fever in laboratory animals. Its possible fundamental significance in relation to spotted fever virus in nature is suggested not only by its host relationships, but by the fact that it is the only tick which occurs in all parts of North America where Rocky Mountain spotted fever has been recognized in man; also by the further fact that ticks of this species, collected beyond the known geographical limits of human infection, produce in test guinea pigs a reaction that suggests the presence of spotted fever virus. Unfortunately, however, this reaction is not always specific. Be this as it may, the fact

remains that through its host relationships and its importance as an agent in the intensive local distribution of the virus in nature, this tick which does not bite man, is nevertheless an indirect factor of greater or less consequence in human infection.

Less is known concerning *D. parumapertus* than of any of the species discussed above. Experimentally, we have found it more difficult to rear. However, stage-to-stage survival of spotted fever virus has been shown under laboratory conditions and it appears quite probable that within its natural geographical range it functions as an agent in the transmission of spotted fever among rabbits. If it does so function, then it is likely to be an indirect factor in infection in man within the portion of its range that overlaps that of *D. andersoni*.

Brumpt (1933) has shown that the virus of spotted fever can be experimentally transmitted by the European tick, *D. reticulatus* (Fabricius) and *H. concinna* Koch. His data indicate that the latter transmits a low-grade virus like its American relative, *H. leporis-palustris*. This and other contributory evidence suggest that some factor resident in ticks of this genus acts as a virus-attenuating agent.

TULARAEMIA.—*Bacterium tularense* is the etiological agent of tularaemia. This disease has an even wider proved distribution within the United States than does spotted fever. It appears to be less well established in nature in the northeastern section. Human infection has been reported in all states but Connecticut and Vermont. Like spotted fever, it is being more and more frequently recognized by physicians, and each year cases are reported from new localities. A wide variety of our small native mammals and some of the larger ones, as well as some species of birds, are susceptible in greater or less degree.

Infection of man results from direct or indirect contact with infected animals or from the bites of certain blood-sucking parasites that infest both susceptible animals and man, or from contact with the infected tissues or excrement of such parasites. Although animal contacts are by far the most common and widespread means of infection, there are certain sections of the country in which transmission by parasites is of major importance. This is particularly true in the Rocky mountain region and adjacent areas. Deer fly transmission is a dominant factor in Utah and has been reported in Oregon, Colorado, Idaho, Wyoming and Montana. *D. andersoni*-caused cases occur in this same area, but are especially frequent in Montana, Idaho and Wyoming. In Montana they have recently been more prevalent than animal-contact infections, doubtless due in part, at least, to the effect of popularized knowledge of the danger of rabbit contacts. In the west the evidence strongly suggests a cyclic prevalence in nature, and this is fully reflected in the occurrence of infection in man. The percentage of infected *D. andersoni* appears, at times, to be quite high.

East of the Rockies, tick-caused cases have been less frequently noted. Most of those reported have been in the south-central states; very few from the far east. Tick-caused cases in Minnesota have been attributed to *D. variabilis* by Hansen & Green (1929). Green (1931) has found naturally infected *variabilis* in Minnesota and we have shown infection

in specimens collected in Iowa. Probably this tick has been responsible for many of the tick-bite cases occurring within its eastern range, but it is also possible that some of these cases have been due to other species not yet shown to be natural carriers.

In the Pacific coast region, field groups from the Rocky Mountain Laboratory have repeatedly collected *tularense*-infected *D. occidentalis* in California and Oregon. This tick infects man and likely plays a more important rôle than has thus far been demonstrated.

We have also collected naturally infected *Ixodes ricinus californicus* in southwestern Oregon (Davis & Kohls 1937). It must certainly be a potential agent in human infection and likely is an actual one.

Tick transmission of tularaemia by *D. andersoni* and stage-to-stage continuity of *Bact. tularense* in ticks were first demonstrated at the Rocky Mountain Laboratory in 1924 (Parker, Spencer & Francis). Transmission by *H. leporis-palustris* and the infectiousness of tick excrement were also reported. In 1926 generation-to-generation survival of the infection was shown (Parker & Spencer), this being the first evidence of such survival of a pathogenic bacterium in an arthropod vector. Similarly, Philip & Jellison (1934) have shown stage-to-stage and generation-to-generation survival of *tularense* in *D. variabilis*.

Tick-caused infection in man may result from tick bite or from contamination of the skin or mucous membranes with the highly infectious tick excrement or crushed tissues of the ticks. Cases of the oculo-glandular type have followed the rubbing of the eyes with a finger contaminated with tick excreta. Excrement retained in sheep wool is an occasional source of infection.

Tick-caused cases occur mostly in the spring and early summer, deer fly cases in the late summer and fall; that is, during the respective seasons in which these parasites are active. In the south a few tick-caused cases have been reported in the fall. Animal-contact cases occur at all seasons, but particularly during that season in which the hunting of rabbits is legalized in the particular state concerned. In the east, therefore, most such cases are reported during the late fall and early winter. In animal-contact infections, the initial lesion is usually on the hand, in deer fly cases on the neck or other exposed part of the body, while in tick cases it is commonly on some part of the body covered by the clothing.

In unreported experiments we have secured the following positive transmission results with ticks that bite man but are not known to be natural carriers of tularaemia: larval-to-adult survival of *Bacterium tularense* in *R. sanguineus* and *A. americanum;* and transmission by *D. parumapertus* adults infected as adults. The first two species may justifiably be considered as potential agents of human infection.

Tests of *O. coriaceus* have shown survival of the bacterium, but transmission experiments so far have been unsuccessful.

It is perhaps of interest to note that *tularense* infection frequently kills infected ticks, as reported by Philip & Jellison (1934). This appears to occur less often in *D. andersoni* and *H. leporis-palustris* than in other species. This is in contradistinction to the mutual adaptation that usually exists between pathogens and their arthropod vectors.

Although tularaemia is transmissible by other parasites, ticks probably play a major rôle in the natural maintenance and transmission of the disease and are therefore an indirect but important factor in animal-contact infections in man. Possibly the most important tick thus involved is the rabbit tick, which is an agent of tularaemia transmission among snowshoe hares, cottontail rabbits and certain ground-frequenting game birds. *D. andersoni* is more important in the case of the jack rabbits. It is very likely that species of *Ixodes* are also involved in transmission in nature, but thus far there has been no experimental work with ticks of this genus, and the only field observation is the one concerning *I. ricinus californicus* as noted above.

In 1933 Parker, Philip & Davis published evidence secured during the investigation of an epizootic in sage hens suggesting that the bird tick, *H. cinnabarina*, may be a carrier of tularaemia among susceptible species of birds. This tick, therefore, is also a possible indirect factor in human infections acquired from game bird contacts or a possible direct factor in case of contamination of the hands or other parts of the body with the crushed, infected tissues of bird ticks, a circumstance that could easily occur during the handling of game birds carrying infected ticks.

Colorado Tick Fever.—This disease is of unknown etiology. The first authentic clinical account appears to have been by Kieffer (1907), but it was not until Becker's studies in Colorado (1930) that it was really accepted as a disease entity. The infection is prevalent in various parts of the mountainous sections of Colorado, over a considerable portion of Wyoming, and occurs to some extent in northeastern Utah and perhaps in southeastern Idaho. Geographical distribution, its occurrence following tick bite, and the identity of ticks taken from persons ill with the disease all point to *D. andersoni* as the transmitting agent. Both the subjective and objective symptoms are quite similar to those of spotted fever, but the fever is of the remittent type and there is no rash. Also, there is no cross-immunity between the two diseases. One of the important diagnostic points is a low leucocyte count.

As compared with spotted fever or tularaemia, Colorado tick fever is a relatively minor problem. It is far more restricted geographically; there is little danger of a fatal termination except in rare instances in persons of advanced years; and the duration of illness is shorter and convalescence is more rapid. Within the limits of its geographical occurrence, however, it is of some economic importance.

Tick Paralysis.—This malady was described by Dr. I. U. Temple of Pendleton, Ore., in 1912. It is an ascending paralysis of the flaccid type and is associated with the attachment of an engorging female *D. andersoni*. Onset usually takes place three or four days after the tick begins feeding. The paralysis begins in the lower extremities and gradually ascends, and if the offending tick is not discovered and removed, death usually results. On the other hand, if removed, or if the tick completes engorgement and detaches before the paralysis is too far advanced, recovery is rapid. The specific cause is uncertain, but it is commonly assumed to be a tick-transmitted toxin rather than an infectious agent. If it is a toxin, however, it is odd that its geographical occurrence is not

coextensive with that of the tick. It has been most often reported from an area which includes the south central and southeastern portions of British Columbia, eastern Washington, northeastern Oregon, northern Idaho and northwestern Montana. It is of most frequent occurrence in British Columbia. Rare cases have been reported from southeastern Oregon, southern Idaho and eastern Montana, and one from Wyoming.

There is no apparent reason to believe that there will be any considerable increase in its prevalence, but it would not be surprising if other North American ticks should be found to be occasionally concerned.

A similar condition in man is caused by the bite of another tick in Australia, and apparently analogous conditions associated with tick bite occur in domestic animals in the United States, Australia and Africa.

RELAPSING FEVER.—Relapsing fever is an infection due to spirochetes and characterized by alternating paroxysms and remissions. Although it is a serious illness, the tick-borne type, as observed in the United States, is not likely to be fatal.

Transmission is by species of the genus *Ornithodorus*. Two are proved vectors and two others may be considered potential ones.

Although relapsing fever has been reported at various times and places in the United States since 1844, it was not until the observations of Weller & Graham in central Texas in 1930 that it was realized that a tick-transmitted type was endemic. It has now become apparent that cases reported in Colorado by Meader (1915) and Waring (1918), in California by Briggs (1921) and in Texas ky Cormick (1927) were likely of endemic origin. Since 1930 cases have been reported from Arizona (Bannister 1930), Nevada (Magee 1930), California (Varden 1932), Kansas (Closson 1934), New Mexico (Short 1934), Washington and possibly Montana (Tollefsen 1935) and British Columbia (Palmer & Crawford 1932). In 1933, a species of *Ornithodoros*, since identified as *hermsi*, was collected by us in a mountain cabin near Moscow, Idaho. Three members of the owner's family gave a history of illnesses very suggestive of relapsing fever. It may confidently be expected that more areas of infection, some in new states, will be reported within the area included in the now outlying foci in Texas, Kansas, California and British Columbia.

The transmitting agent has been identified definitely in only three of the states listed, *i.e.*, *Ornithodoros turicata* in Texas and *O. hermsi* in California and western Nevada. However, recent observations made by Davis suggest that *turicata* is the vector in southwestern Kansas. In fact three strains of spirochetes have been isolated from specimens of this tick collected at three localities in Clarke county. These strains are apparently identical, but appear to differ immunologically from the spirochete carried by the same tick in Texas.

Conditions incident to the cases reported in Arizona suggest that *O. hermsi* is a likely vector in that state. *O. talaje*, which occurs in California and Arizona, is a known agent of transmission in Panama and should be kept in mind as a potential carrier.

O. parkeri also falls in the category of a potential vector. Only two cases have been reported (Tollefsen 1935) within its range as now known (Wyoming, Montana, Washington, and Utah). Moreover, we have iso-

lated strains of spirochetes from ticks of this species collected this past summer from Richardson ground squirrel burrows near Dillon, Mont., but do not yet know if this spirochete is infectious for man.

Herms & Wheeler (1936) have been unsuccessful in experimental attempts to transmit California strains of relapsing fever with *O. talaje*, *O. coriaceus*, and *O. turicata*.

R. sanguineus, reported by Sergent to transmit *Spirocheata hispanica* in Algeria, is, as previously stated, an unknown factor in disease transmission in the United States. *D. andersoni* has been suggested as the possible vector of relapsing fever in British Columbia but this seems quite unlikely.

Transmission of relapsing fever spirochetes by the penetration of the coxal fluid into the tick bite wound has been suspected in the Old world, but there is no evidence of transmission by other than the tick bite in this country (Kemp, Moursund & Wright 1936, Herms & Wheeler 1936, and unpublished data of the Rocky Mountain Laboratory).

Small wild mammals appear to constitute a reservoir for relapsing fever spirochetes. This possibility was first suggested by Nicolle & Anderson (1927) and the common occurrence of the transmitting ticks in rodent habitats and the repeated demonstration of spirochetes in rodents lend support to this hypothesis. In California, Porter, Buck & Stevens (1932) reported natural spirochete infections in chipmunks and tamarack squirrels. In Texas, Bohls & Schuhardt (1933) have found armadillos and opossums to be naturally infected. Certainly, generation-to-generation continuity of the infectious agent in ticks, which has been repeatedly demonstrated and which has been shown in this country in both *O. hermsi* and *O. turicata*, must play a prominent part in natural maintenance.

O. hermsi apparently is prevalent only at high altitudes, *i.e.*, above 5000 feet, and infections due to this tick are usually contracted in poorly constructed, nonrodent-proof cabins or summer dwellings in the mountains. *Turicata*, on the other hand, occurs at lower altitudes and seems to frequent dwellings to a much less extent, at least in this country; infections are usually contracted by contact with the tick in nature, as for example, by entering tick-infested caves or by contacting rodent burrows or habitats. It is likely that *parkeri*, like *turicata*, seldom frequents dwellings.

Boutonneuse Fever.—This relatively mild Rocky Mountain spotted fever-like infection, first described from Tunis in 1910, is now known to be of wide distribution in southern Europe and northern Africa, and probably occurs in southwestern and perhaps southern Asia. The sole known transmitting agent is the cosmopolitan brown dog tick, *R. sanguineus*.

Boutonneuse fever and spotted fever are evidently closely related, since laboratory animals recovered of either are completely immune to the other. However, there are serological differences as well as an apparent antigenic difference between the viruses, as indicated by the failure of Rocky Mountain spotted fever vaccine to afford protection against boutonneuse virus (Davis & Parker 1934).

Although boutonneuse fever has not been reported in the United

States, this is no positive evidence that it is not present. The occurrence of the known vector suggests that the possibility of its occurrence should be kept in mind.

OTHER CONDITIONS ASSOCIATED WITH TICK BITE

Besides the diseases discussed above, pathological conditions of wide variety have been reported as due directly or indirectly to tick bite. These range from inconsequential local lesions to septicaemic infections terminating in death. In order to round out the picture of the tick-caused disease field, some of these conditions will be cited very briefly.

The most frequent is a lesion at the site of bite. Usually such lesions are transient and of mild character, causing only a minor degree of inflammation, swelling or itching, but sometimes the lesion is severe and may be persistent and there is occasionally systemic involvement. Ulcers of varying size and description are not infrequently reported, often with accompanying necrosis, sometimes quite resistant to treatment and in rare instances requiring surgical intervention. Cases of local chronic inflammation with more or less extensive induration are not uncommon, and rare individuals exhibit this reaction to each bite received. Surgical removal of the involved tissue may become necessary, sometimes years after the inciting bite. "Boils," "carbuncles" and "abscesses" have been reported, also localized or general adenitis. The bites of certain species of ticks are particularly likely to be very irritating or painful, notably of *A. cajennense*, *Ixodes ricinus californicus*, *O. talaje* and *O. coriaceus*. Occasionally ticks cause trouble by attaching in the ear, *O. megnini* being the chief offender.

Lesions due to tick bite are frequently attributed to broken off mouth parts left in the skin when a tick is removed. As a matter of fact this seldom happens except with ticks having long hypostomes, such as *I. ricinus californicus*, *A. americanum* and *A. cajennense*. The dermacentors, with shorter mouth parts, can ordinarily be safely removed by gentle pulling, in spite of widely held popular ideas to the contrary.

There are other conditions, usually infectious, in which constitutional symptoms are generally present. Staphylococcus infection, streptococcus septicaemia, and metastatic infection are sometimes reported. Streptococcus infections have occasionally resulted in death. Such infections may or may not always be of secondary nature.

Certain febrile reactions that follow tick bites are believed by some physicians to result from multiplicity of bites, no infectious agent being concerned. A somewhat similar reaction, however, may be induced by the bite of a single tick, as illustrated by the case of a child seen by one of the authors (Parker) several years ago. Following the bite of an *Ixodes* species unknown, the child became irritable, temperature reached 103.6°F and pulse rate 120. The tick was found and removed and the patient became normal within 24 hours. Within a month she was again bitten, this time by a male *D. andersoni* with exactly the same resulting symptom complex. The temperature reached 104°F and the pulse rate 130. With the removal of the tick, the symptoms again subsided rapidly.

Other febrile conditions suggesting possible specific tick-caused infections of unknown etiology have been reported. In this connection, it may be mentioned that during the 15 years that the Rocky Mountain Laboratory has been in existence, we have repeatedly encountered unrecognized disease conditions in laboratory animals following tick bite, or after tick injection. More recently it has been possible to give some time to the study of such diseases. In 1934, a filterable virus was isolated from *D. andersoni* collected near Nine Mile, Mont., and in 1935 two strains of a closely related, perhaps identical virus, were recovered from *D. occidentalis* collected near Grants Pass, Ore., (unpublished data). In 1936, four bacteria, which have not been identified with described organisms, were isolated from *D. occidentalis*, *H. leporis-palustris* and *D. variabilis*, from California, Oregon and Iowa, respectively. All these disease agents are highly pathogenic for laboratory animals, but we do not yet know whether any are of significance in human disease. Part of them, including the virus strains, we have already transmitted experimentally with ticks.

Discussion.—Five tick-borne diseases of man are now known to be endemic in the United States—Rocky Mountain spotted fever, tularaemia, relapsing fever, Colorado tick fever and tick paralysis. One or more of these diseases occur in each of 46 states (all but Connecticut and Vermont) and tick transmission has been proved in 37. The three sections of greatest incidence are the Rocky mountain region and adjacent areas, Texas, and an area near the mid-Atlantic coast, extending through Maryland, Virginia and North Carolina.

Five species of ticks have been incriminated in the transmission of these diseases, five others are considered as potential vectors, and three more are recognized as actual or possible indirect agents of infection because of their known or suspected rôles in the natural maintenance of certain of the pathgens concerned. There is at least one of the proved vectors in each state, some have two or three, while California has all five. Each state also has one or more of the additional species mentioned as of potential or indirect importance.

The efficiency of native ticks as agents in the transmission of pathogenic microorganisms can best be brought out by three statements—one listing the number of such agents that one species of tick can transmit, a second citing the number of tick species that can transmit one pathogen, and a third showing the diverse character of the disease agents transmitted.

The Rocky Mountain wood tick, *D. andersoni*, is a modern Pandora's box. It is the known vector of the causative agents of four diseases—Rocky Mountain spotted fever, tularaemia, Colorado tick fever and tick paralysis. In addition to these agents of known pathogenicity for man, three bacilli from this tick were described by Noguchi (1926) and at the Rocky Mountain Laboratory we have isolated numerous others. Filterable viruses (possibly identical) which are pathogenic for laboratory animals, have been isolated both by Noguchi and by us. And in the field of animal diseases, Rees (1931) has shown experimentally that *andersoni* will transmit anaplasmosis of cattle, while Syverton & Berry (1936) report laboratory transmission of equine encephalomyelitis.

Rocky Mountain spotted fever will be used as an example to show the number of ticks that can transmit the same pathogen. *Dermacentroxenus rickettsi* is transmissible by eight ticks representing four genera—*Dermacentor*, *Haemaphysalis*, *Rhipicephalus* and *Amblyomma*. Three species are proved vectors while five are known to be equally efficient transmitters under laboratory conditions. It has been previously mentioned that two European species are also laboratory-proved vectors. Probably numerous other ixodid ticks would be equally good carriers.

The disease agents known to be carried by our native ticks belong to four diverse groups of pathogens—the rickettsiae, the bacteria, the filterable viruses and the spirochetes. On experimental evidence, the anaplasmas may be added.

However, ticks not only transmit the infectious agents listed, but also function in their perpetuation in nature. They do this by serving as a medium for the survival of such agents during the winter or over other long periods during which the tick may not contact a susceptible host animal. Female-to-larvae survival of pathogens by passage through the egg stage also plays a part. This phenomenon has been shown with the causative agents of Rocky Mountain spotted fever, tularaemia and relapsing fever. Sex-to-sex transmission during copulation may also be involved, and certain chance observations that we have made, but which have never been verified, suggest some pathogens may remain inactive in ticks through a considerable number of successive stages, later becoming active again under suitable stimulation.

In bringing this paper to a close, it is desired to direct attention to a rather obvious point, but one that it is felt is not emphasized sufficiently, namely, that the infectious diseases that ticks transmit to man are primarily diseases of the native fauna. Occurrence in the former is purely fortuitous, since man is neither a normal host of ticks nor of the disease agents that they transmit. But while it is evident that knowledge of these diseases in man is essential, that it is necessary that their transmitting agents be known, and that the bionomics of the vectors should be studied, yet on the other hand, we wish to venture the opinion that more fundamentally valuable information can ultimately be obtained by the investigation of such diseases and their causative agents in nature. We have carried on such studies to some extent and realize fully the time, difficulties and disappointments involved. However, since the importance of nature as a source of human disease has become so well recognized, it should now be feasible to reverse the usual order of research by undertaking a thorough survey of the native fauna to determine just what parasite-transmitted disease agents are actually present, how they are perpetuated, and which ones are of present or of possible future concern to man.—1-18-37.

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Need for Research on Parasitic Mites

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It is not my intention to offer any prolonged discussion of the paper just read. I am sure every member present will join me in congratulating Dr. Parker on his excellent presentation and thank him for the

masterly manner in which he has summarized the present state of our knowledge in regard to the ticks of the United States in relation to human disease. The paper needs to be read several times in order to grasp the significance of the important part ticks play in human affairs. Had the author included a discussion of the important relations of ticks to our domestic and game animals, and the diseases they transmit we would be even more keenly aroused to the great importance of this field of investigation.

What impresses me is the admirable cooperation that has existed among all the workers that have been engaged in the study of ticks and tick-borne diseases. Beginning with the work of Dr. Theobald Smith of the Bureau of Animal Industry we have witnessed that Bureau continue and extend its work, the Bureau of Entomoloy, the Montana State Board of Health and its Board of Entomology, the U. S. Public Health Service, the veterinary and medical schools, and the many private physicians and investigators have all contributed in enabling Dr. Parker to give us his splendid summary today. The only fly in the ointment is that except for the admirable work of the Bureau of Entomology, the entomologists of Montana and more recently the work in California, we entomologists cannot claim to have played the part we should have done. Though a few of us have been and still are interested in ticks we appear to be unable to impress upon our superiors the importance and imperative need for research on ticks and parasitic mites in general. I feel very strongly that our two national entomological societies should take active steps to bring such matters to the attention of our state colleges, universities and experiment stations.

With the present exuberant activity of national and state game commissions for the preservation and increase of our wild game, research along these lines becomes more imperative. Game animals of all kinds with their diseases and parasites are being distributed from one section of the country to another. The airplane and motor car are now employed so extensively in the distribution of living animals that it will be only a matter of a few years until all our native and introduced parasites are distributed over the entire country. Wherever conditions are favorable these various species will remain and become part of the fauna. I need only refer to the tick *Rhipicephalus sanguineus* Latr. recorded from the southern tip of Texas in 1912. In 1930 I could find no published records of its further spread but a few years later it was reported widespread throughout the southern, eastern and central states and as far north as Massachusetts and Illinois. In 1931 I recorded a typical house infection in western New York by *Ornithodoros talaje* Guérin-Mén. This tick was taken in every room in the house and I have definite records of its presence there for five years despite efforts to destroy it. In Wisconsin Herrick (1935) reports private houses, clubs and rooming houses infested with this tick for at least five years. Riley (1935) records somewhat similar conditions in Minnesota.

How this tick has managed to survive is rather puzzling since all reports indicate that man was not bitten and the captured specimens were not engorged.

Dr. Parker refers to the effects of the bite of an unknown species of *Ixodes* on a young child. I can record quite different results from the bite of *Ixodes hexagonus* var. *cookei* Pack. The tick was deeply embedded in the scalp of a 2-year old child. The presence of the tick caused no noticeable symptoms and its removal left no apparent scar. The father of this child was later bitten by the same species of tick in the axilla of the left arm. After the removal of the tick he suffered pain for over two weeks and noticed the effects for almost a year, causing what he considered a local arthritis.

In closing I wish again to emphasize the need for extended work along the lines indicated by Dr. Parker and his able associates of the Rocky Mountain Laboratory of the U. S. Public Health Service. I hope the entomologists will shoulder their share of the work.—1-7-37.

EASTERN BRANCH

PAPER-READING SESSION, EIGHTH ANNUAL MEETING

New York, N. Y., November 1936

Observations on Shade-tree Insects and Their Control

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On June 12, 1936, a mealybug differing from other species of *Pseudococcus* was found infesting the yew, *Taxus cuspidata*, on an estate at Greenwich, Conn. Specimens were sent to George Rau, West New York, N. J., for determination. Mr. Rau, after checking over the species with Dr. Harold Morrison, Bureau of Entomology and Plant Quarantine, Washington, D. C., declared it to be new and will publish a description in the near future. So far, both the range and the degree of infestation of this mealybug have been decidedly limited. It has not been seen to produce the heavy masses, hanging in festoons, on the host that are so characteristic of Comstock's mealybug, *Pseudococcus comstocki* Kuw., which usually reaches a point of maximum abundance early in the fall. A heavy infestation of Comstock's mealybug was found on September 29, 1936, on *Taxus cuspidata* on an estate at Greenwich, Conn.

For several years it has been noted that the needles of red, Scotch, white, Jeffrey and other pines in ornamental plantings near Stamford, Conn., have been spotted with yellowish or reddish at different times during the season, the spots frequently coalescing and the needles dying or dropping prematurely. Microscopic examinations disclosed in many cases a puncture, evidently that of an insect, and a subsequent invasion of a secondary or saprophytic fungus. In some cases this injury was attributed to the work of aphids, but this could not be accepted as a complete explanation as the spotting developed on needles of trees where no aphids could be found. During late fall of 1935, psyllids were

noted quite commonly on many of the trees where this spotting of the needles had occurred. The psyllids were found puncturing the needles again early in the spring of 1936, but they soon disappeared. Needles on which the psyllids were observed feeding were marked and in many cases the characteristic spotting developed later.

The psyllid was identified by P. W. Oman of the U. S. Bureau of Entomology and Plant Quarantine as *Trioza tripunctata* Fitch, which infests blackberry during the summer. After the leaves of the blackberry have fallen in the autumn, the psyllids migrate to the pines where they feed until the advent of freezing weather, whereupon they hibernate, appearing on the needles again early in the spring.

During the summers of both 1935 and 1936, the linden leaf aphid, *Therioaphis tiliae* Linn., was very abundant on many ornamental lindens, injuring the foliage and producing copious amounts of honeydew in which sooty-mold developed, blackening and disfiguring the tree and its surroundings. This has constituted the most serious pest of ornamental lindens in the Stamford area, and has so affected the status of the linden as an ornamental tree that removal and replacement by other species is being contemplated on several estates. This aphid can, however, be controlled by several timely and carefully applied contact sprays.

Spittle insects, *Aphrophora parallela* Say, were abundant on Scotch and other pines during the summer of 1936. A comparative test was conducted with 40 per cent nicotine sulfate 1:800 plus a summer oil 1:200; a pine-oil emulsion (*Palustrex*) 1:400 plus 40 per cent nicotine sulfate 1:800; and a pyrethrum soap (*Red Arrow*) 1:400 plus crystal potassium oleate 1:200. The last two gave complete control and the first only partial. None of these sprays resulted in foliage injury.

Both the eastern tent caterpillar, *Malacosoma americana* Fabr., and the fall cankerworm, *Alsophila pometaria* Harris, were abundant in the Stamford area in the spring of 1936, but neither reached the outbreak proportions of 1935. The use of arsenate of lead in the delayed-dormant oil spray has been found materially to reduce the infestation of tent caterpillars by killing large numbers of the hatching larvae. Effectiveness of this spray increases as it is timed near the hatching of the eggs, the earlier applications being less effective, although increasing the dormant oil concentration from the usual 1:16 to a heavier concentration of 1:10 with the arsenate of lead added has been found to give a very high control when applied considerably in advance of the hatching of the eggs. Concentrations of *Sunoco* oil 1:10 with arsenate of lead, applied in the spring before the leaves separated in the bud, did not produce injury on apple trees and in addition to giving an excellent control of the tent caterpillars also reduced the hatching of the fall cankerworm to a considerably greater extent than the use at this time of arsenate of lead alone or arsenate of lead in combination with a weaker dilution of oil.

Although an outbreak of the eastern tent caterpillar is spectacular and causes a great deal of popular concern, the cankerworm is by far the more destructive to shade trees. Spraying with poison is the most effec-

tive control and an early application usually gives a better protection to the trees than a later spray. However, during severe outbreaks two poison sprays are frequently necessary to obtain control, particularly on certain types of trees. Control of cankerworms is difficult on hickories, ash, butternut, walnut and some other trees, possibly because the leaves are later in unfolding and present a comparatively smaller amount of leaf tissue at first so that the feeding of the caterpillars destroys a larger proportion of the foliage than in the case of the earlier starting trees. Very probably the leaf texture is a factor also.

Tent caterpillars and cankerworms are subject to the attacks of a great many natural enemies. Natural control, however, is a factor which cannot be relied upon. It is imperative to spray for the protection of shade and ornamental trees. Since natural factors periodically control such outbreaks, observations were made in the Stamford area upon the principal agencies involved.

The increase of an organism is invariably followed by an increase in its natural enemies. During the peak of infestation of the fall cankerworm at Stamford in 1935, three predacious ground beetles of the genus *Calosoma*, ordinarily rare in this area, became abundant and fed extensively upon the cankerworms. These were *Calosoma frigidum* Kby., *Calosoma willcoxi* Lec., and *Calosoma scrutator* Fabr. Their relative abundance was in the ratio of 20:10:1. In other words, *C. frigidum* was about 20 times as common as *C. scrutator* and twice as numerous as *C. willcoxi*. All three are arboreal species readily climbing trees in their search for the cankerworms. There was no decided increase in our usually common *Calosoma*, *C. calidum* Fabr., which is a terrestrial species and feeds largely on ground-dwelling caterpillars.

The abundance of these *Calosoma* beetles in the defoliated woodlands was in turn influenced by skunks which were attracted to and fed upon the beetles in great numbers as they came to the ground to oviposit. Another enemy of the *Calosoma* beetle, a histerid beetle, *Hister immunis* Er., determined by Charles A. Ballou, Jr., increased with the number of *Calosomas*, killing the young larvae and probably feeding on the eggs.

To just what extent these beetles were responsible for the reduction of the cankerworms is problematical. Parasitic flies attended the outbreak as well, the most abundant being the tachinid, *Pseudotachinomyia webberi* Smith, determined by H. J. Reinhard, but probably the beetles killed more cankerworms than the flies, since the beetles fed on both unparasitized and parasitized alike. Under and on an unsprayed hickory tree more than 50 *Calosoma* were noted for several days during June 1935. This tree was completely defoliated in 1935, but in 1936 the cankerworm infestation produced only a ragging of the foliage. Were the *Calosoma* the factor, or were there other influences of greater importance? In the woodland nearby the cankerworm moths of both sexes appeared in great abundance in the late fall of 1935 in spite of the large numbers which undoubtedly had been killed by the *Calosoma;* and in the spring of 1936 cankerworm egg masses were more abundant than at the same time last year. On this basis, a heavier infestation was expected than in 1935, but this did not materialize. The cankerworms were abundant in

1936, but there was much less defoliation than in the preceding year. For one thing, the hatch was very incomplete. Many egg masses for some unknown reason produced only a few caterpillars. Some of the eggs were destroyed by hymenopterous egg parasites, but other factors were involved. In the spring of 1936 there were several late frosts which undoubtedly destroyed some of the newly hatched cankerworms. After the most severe frost, young dead cankerworms were found hanging from the trees. The death of these particular individuals can be ascribed only to this cause.

The eastern tent caterpillar, which was so abundant in the Stamford area in 1935 as to defoliate most of the unsprayed wild cherries and apples, was sufficiently numerous to cause considerable damage in 1936, but was much less abundant than in 1935. During 1935, observations were made on the natural factors affecting their numbers. There was a considerable mortality of caterpillars during the season which we roughly approximated as being accounted for by the following:

Destroyed by wilt and fungus diseases, 30 per cent (the wilt disease caused by a filterable virus being by far the most prevalent; in 1936 this disease destroyed a much higher proportion than in 1935); killed by hymenopterous and tachinid parasites, 25 per cent (of these the most numerous were the ichneumonid parasites of the old genus *Pimpla*, *Ephialtes pedalis* Cress and *Iseropus coelebs* Walsh); died from undetermined causes (starvation, malnutrition or other influences of overcrowding) and killed by predators, including birds (of which the cuckoos, orioles and bluejays were most important in the Stamford area), and insects (soldier bugs, lady bird beetles and ground beetles principally), 20 per cent. The hymenopterous egg parasites which usually increase after the caterpillar population starts its decline became abundant in the summer of 1936.

Paradoxical as it may seem, there is evidence to indicate that the fall cankerworm may be one of the important factors in reducing the number of tent caterpillars under certain conditions. In several areas under observation in 1935 wild cherry and apple trees in waste tracts were defoliated by the tent caterpillars and the defoliation period was extended by the feeding of cankerworms later. As a result the trees were nearly leafless when the tent caterpillar moths were flying and were apparently unattractive to them for egg deposition, as very few egg masses could be found on the leafless trees. In nearby trees which for one reason or another had not been defoliated by cankerworms, tent caterpillar egg masses were abundant. A somewhat similar interrelation was noted between the cankerworm and the pin-oak leaf roller, *Argyrotoxa semipurpurana* Kf. On a number of trees where these leaf rollers were abundant every year, the supernumerary cankerworms defoliated the trees in 1935 and starved out the leaf rollers.

While arsenate of lead still remains the most effective spray for protection of trees from damage by tent caterpillars and cankerworms, there are certain situations when a nonpoisonous spray may be required. For the larger, more resistant insects, a pyrethrum–soap spray is usually quite effective, but it has its limitations. In 1936, tests were conducted

with several brands of pyrethrum powder and cubé powders applied in a mixture of summer oil 1:200 as contact insecticides. In general, results on exposed tent caterpillars were better than on cankerworms. One or two commercial brands of derris powders gave an excellent kill of exposed tent caterpillars at the rate of 3 pounds of 4 per cent powder to 100 gallons of spray. The cubé powder appeared slightly less toxic, requiring larger amounts of material. The pyrethrum powder in the oil emulsions was invariably less toxic than the pyrethrum-extract soap sprays and less toxic to the older tent caterpillars than the derris.

An atrocious method of banding for the control of cankerworms came to notice this season. Essentially, it is the removal of a strip of bark 3 to 5 inches wide and some three-eighths of an inch deep around the tree. This practically exposes the cambium and then a liberal amount of a presumably standard adhesive banding material was applied to the barked area. This was done on hundreds of trees in a central New York locality. There is evidence to indicate that even hardy elms may be severely damaged, and in at least one case, large trees, elms and lindens, treated in this manner died within two to seven years after banding. It is considered inadvisable to apply the ordinary banding material directly to the bark of a tree.—12-18-36.

Poisoning of Honeybees by Rotenone–Derris Dusts

ROBERT S. FILMER, *New Jersey Agricultural Experiment Station, New Brunswick*[1]

Poisoning of honeybees by agricultural dusts in the vegetable areas of central and southern New Jersey has become a major problem for beekeepers in these areas. In the past all severe cases of poisoning of honeybees have been definitely traced to the use of arsenical dusts or sprays for insect control. The majority of cases have been concerned with arsenical dusts drifting onto adjoining fields which contain plants from which the bees were obtaining nectar or pollen. These instances have been so common in the past that all reported cases of poisoning from the vegetable areas are thought to be due to arsenical poisoning.

During the last season a severe case of poisoning of honeybees was brought to our attention, which from casual examination appeared to be a typical case of arsenical poisoning. However, a careful check-up of the situation, which included a survey of the surrounding territory as well as chemical analysis of dead bees, failed to reveal any possible evidence of arsenical poisoning. As the circumstances concerning this case appear to indicate that derris or rotenone dust was responsible for the poisoning, the following information is presented.

On July 17 a beekeeper had placed 37 colonies of bees in the lima bean fields near Findley, N. J. The colonies were visited about noon on July 21 and the owner reported that the ground in the vicinity of the hives was

[1] Paper of the Journal series, New Jersey Agricultural Experiment Station, Department of Entomology.

covered with dead bees and that there were still a few sick and crawling bees leaving the hive. A visit to the yard was made on the forenoon of July 22 and conditions were found much as the beekeeper had reported with the exception that no sick or crawling bees were found. Dead bees covered the ground for a distance of 25 to 30 feet from the hives. There was a tendency for bees to collect in piles in depressions in the ground and dead bees could be found clinging to standing grass and weeds in the vicinity of the hives. Examination of dead bees did not show the abdomen to be blocked or distended in all cases. Both field and nurse bees had been killed. Examination of the hives showed colonies weakened until only the queen and a handful of young bees remained. Examination of the brood showed no dead or discolored larvae but as the unsealed brood had been neglected the larger larvae were wriggling upon the cells. As the symytoms were typical enough to suspect arsenical poisoning a survey of the neighborhood was made to locate the source of poisoning.

The survey of this area revealed the following facts which seem to indicate that a derris or rotenone dust was responsible for the poisoning.

(1) A careful survey of the fields in the vicinity of the apiary showed that lima bean was the principal crop, with only an occasional field of corn and small wood lots.

(2) All the beans in this area were owned or contracted for by a large canning concern, and all dusts which were applied to the beans were supplied by this concern. A visit to the office of the canning concern resulted in the following information.

(3) This concern owned or had contracted for between 5000 and 6000 acres of lima beans in that immediate vicinity.

(4) The beans were dusted with a three-quarters per cent rotenone dust containing 20 to 25 per cent sulfur and about 15 per cent copper.

(5) Dusts had been applied by airplane on the evening of July 19 and early morning of July 20 to fields that were not in bloom.

(6) With this large acreage of lima beans in a restricted territory the owners had taken every precaution to eliminate poisoning of honeybees and other pollenating insects. Dusts were never applied to fields after the beans had started to bloom and dusts were applied early in the morning and late in the evening where bees and other pollenating insects would be at a minimum.

(7) Examination of the bean fields in the immediate vicinity of the apiary on July 22 showed that the plants in most of the fields were just coming into bloom for the first time, and in the writer's opinion there was an excellent possibility of some bloom being present at the time the fields were dusted. The nearest fields that were in full bloom were about three-quarters of a mile away. Plants in these fields had well-formed beans in the pods, which showed they had been blooming for some time. There were also several large fields within three-quarters of a mile where the plants would not be ready to bloom for several weeks.

(8) Although this area was checked over several times no instance where arsenical dusts had been used was disclosed. Laboratory analysis of dead bees failed to show any trace of arsenic.

(9) There were several apiaries of bees located about one mile from the poisoned apiary that showed no signs of poisoning. These apiaries were bordering on fields of young beans that had been dusted on July 19 and 20, but these beans were not in bloom.

Discussion.—The facts as they are now presented seem to point to a clear case of poisoning by rotenone–derris dusts. Much of the actual proof, however, is lacking because the writer at that time was looking for a source of arsenical poisoning. Many of the above-mentioned details were not obtained until a week or 10 days after the poisoning occurred. With the facts in hand, the logical explanation seems to be as follows: The fields of beans adjacent to the bee yard had some plants in bloom at the time they were dusted on July 19 and 20 and the rotenone dust poisoned the nectar of these plants. There is also a possibility that the dust drifted onto fields where the plants were in full bloom, and likewise a possibility that the honeybees picked up particles of the dust on their legs or bodies while visiting the blossoms of recently dusted plants and that this dust later reached the mouth or had a direct contact action. The fact that nurse bees as well as field bees had been poisoned suggested that the rotenone dust had poisoned the nectar. To check this theory, sugar solutions containing varying amounts of rotenone dusts were fed to colonies of bees. Dilutions of 4 per cent rotenone dusts were added to dilute sugar syrup to make up dilutions containing the following amounts of rotenone—1:2500 = .04 per cent; 1:1250; 1:625; 1:317.

These dilutions when fed to colonies of bees were all toxic with the exception of 1:2500 dilution. The colony fed this solution showed no signs of poisoning and built up normally. The other colonies showed symptoms of poisoning the day following the feeding of the syrup, and in all cases practically all the bees in the colony were killed within 72 hours. The general symptoms were similar to arsenical poisoning, with bees crawling from the hives, the abdomen in many cases being greatly distended.

To check the contact action of rotenone dusts several batches of bees were dusted directly with a three-fourths per cent dust and were then placed in clean cages. Other batches of bees were placed in cages the floor of which had been dusted with a light coating of three-fourths per cent rotenone dust. In these tests a complete kill was obtained in 24 hours.

The above tests seem to be conclusive enough to indicate that rotenone dusts are as toxic to honeybees as the arsenical dusts and that the use of rotenine–derris dusts on agricultural crops may be another serious source of poisoning to honeybees.—12-18-36.

RECENTLY issued revisions of the alfalfa weevil quarantines of California, Iowa, Michigan, Mississippi, Missouri and North Dakota have as their principal change the addition to the infested area of counties in Colorado, Nebraska, Oregon and South Dakota not previously under quarantine. Intrastate quarantines have also recently been placed by state officers of Nebraska and South Dakota.

Life History of the Thrips Parasite *Dasyscapus parvipennis* Gahan

And the Technic for Breeding It

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While the writer, as a representative of the U. S. Department of Agriculture, was searching for the natural enemies of the sugarcane moth borer, *Diatraea saccharalis* F., and other pests in Trinidad, British West Indies, during the winter of 1935–36, for introduction into Puerto Rico and the United States, the government of Trinidad was undertaking the introduction of the thrips parasite *Dasyscapus parvipennis* Gahan from the Gold Coast, Africa. There it was reported by Cotterell (1927, 1928) to be effectively controlling *Heliothrips rubrocinctus* Giard, the red-banded thrips. The object of this attempted introduction was the control of the same pest on cacao in Trinidad, where it has been a serious pest for many years.

Following establishment of the parasite in its new home, the request of the U. S. Department of Agriculture for specimens to introduce into Puerto Rico was generously granted by E. J. Wortley, Director, Department of Agriculture of Trinidad and Tobago, and Sir Geoffrey Evans, Principal of the Imperial College of Tropical Agriculture. Dr. A. M. Adamson, professor of entomology of the Imperial College, rendered valuable aid in facilitating the breeding of the parasite.

History.—*Dasyscapus parvipennis* Gahan was first reported from Java by van Heurn (1923), who several years later sent specimens to Washington for identification by the taxonomists of the Bureau of Entomology. Gahan (1927) described it as a new genus and species in the family Eulophidae. That same year and also in 1928 Cotterell reared it in the Gold Coast without knowing its identity. Ferrière (1931) was the first to record it by name from Africa. It was successfully introduced into Trinidad in 1935 and into Puerto Rico in 1936.

Hosts and distribution.—As *Dasyscapus parvipennis* has been discovered and described comparatively recently, not much is known concerning its hosts or distribution. The species was originally described from adults "reared from *Thrips tabaci* Lind., along with *Thripoctenus brui* Vuillet" from Java. In the Gold Coast and in Trinidad its principal host is the red-banded (cacao) thrips, *Heliothrips rubrocinctus* Giard. Adamson (1936) has bred it in Trinidad also from two undetermined species of thrips. Evidently it is not fastidious as regards hosts. Its introduction into the United States would seem to be highly desirable in view of the presence here of both *Thrips tabaci* and *Heliothrips rubrocinctus*. The former occurs throughout the country on more than two score plants, while *H. rubrocinctus* has been recorded thus far only from Florida attacking mango, jobo and *Acalypha wilkesiana*.

Life history.—The following life-history notes were taken in the course

of the rearing work in Trinidad.[1] The adult of *Dasyscapus parvipennis* lives less than a week under laboratory conditions, usually only four or five days. Although the female will attack the nearly mature host larvae, reproduction is obtained only in the younger stages. In the body of its host the female lays a single egg, which hatches in about 24 hours. The development of the parasite larva is at first very slow, allowing the host also to develop nearly to the prepupal stage. Six days after hatching the parasite larva completes devouring the body contents of the host, leaving only the empty outer skin, through which the fully developed maggot is now easily discernible. The prepupal stage of *D. parvipennis* lasts approximately 48 hours. When the parasite pupates it adheres to the skin of the thrips, which is still attached to the object on which the larva was resting at the time of its death, usually the leaf on which it last fed. There the pupa remains for 10 or 11 days, a jet black and shining object, until the emergence of the adult. The entire lifecycle covers 17 to 21 days. Parthenogenetically the species is arrhenotokous.

Breeding.—The breeding technic developed by Professor F. W. Urich and Dr. A. M. Adamson was used in the work in Trinidad. On February 15, 1936, 38 male and 61 newly emerged female adults of the species were divided into four lots of about equal numbers, and each lot was placed in a glass cylinder 5 inches in diameter and 10 inches deep, closed at the top and bottom by fine muslin held in place by rubber bands. Food was provided in two forms, a 10 per cent sugar solution on white blotting paper and cut raisins, and was renewed daily. Water was provided almost continuously throughout the day by keeping the muslin at both ends of the cylinders moist. On the first day approximately 300 young thrips were exposed to parasitization by each group of *Dasyscapus parvipennis* adults through introduction into the glass cylinders of infested cashew leaves. After 24 hours exposure to the parasites these leaves were removed, and a fresh lot of hosts was made available for attack. On the second day the thrips exposed numbered about 250, on the third day about 200, and on the fourth and fifth days only about 150. Each day the infested leaves that were removed from the glass cylinders were placed in separate battery jars 12 by 7 by 9 inches. These jars had glass tops, but pieces of white blotting paper were placed under the lids and pieces were also placed on the bottom, and the atmosphere was kept humid by moistening the blotting paper at the bottom and top as often as was necessary. Fresh thrips-free cashew leaves were added daily to each battery jar to provide food for the parasitized thrips. During the transfer of the exposed thrips from the cylinders care was taken to prevent the escape of the adult parasites or their removal with the foliage.

Shipment.—From the approximately 4000 immature thrips exposed to the 61 females, 1556 pupae of *Dasyscapus parvipennis* were obtained, all of which were shipped by air express to Puerto Rico on March 2. The safest method of introducing beneficial insects into a new country

[1] Previous investigations by entomologists of Trinidad had determined the host relationships of the species, and consequently no studies were made along this line. All efforts were concentrated upon rearing an adequate supply for shipment. Because of this the life-history notes are fragmentary.

is without doubt sending them in the adult state. In this particular instance, however, an exception was deemed necessary for several reasons, and the parasites were sent to Puerto Rico in the pupal stage. In the first place, the adult *Dasyscapus* is very short-lived, surviving only four or five days; and, since the airplane schedule provided only weekly service between Trinidad and Puerto Rico, it was impossible to synchronize the emergence of adults with the date of departure of the airplane from Trinidad. In the second place, the material shipped was free of hyperparasites, since it was all laboratory bred. Lastly, the long pupal period of the parasite made possible the accumulation of maximum numbers for introduction.

To determine the best method for shipping the pupae of this microscopic insect, a test was made by preparing the material in several ways. Some were allowed to remain adhering to the original leaf on which they pupated; some were attached to heavy cardboard by means of plain water; another lot was affixed by the use of gum arabic; while a fourth lot was placed on the moistened glue on the back of postage stamps. Results indicated that there was only an insignificant difference in the percentage of adults emerging from the pupae prepared for shipment by the first three methods. The first two methods produced an emergence of approximately 75 per cent, the use of gum arabic reduced emergence to 67 per cent, whereas the glue on the back of postage stamps seems to have been responsible for a further reduction in emergence to about 55 per cent.

Recovery.—Dr. K. A. Bartlett, who received the shipment from Trinidad, cared for the emerging adults and made the field liberations, informed us upon our return to Puerto Rico late in May 1936 that he had very recently made the initial recoveries at the site of the original liberation on the western end of the island. Thus the desire and fond hope of every entomological explorer, the definite establishment in their new home of the beneficial insects he sends, were realized, and in this case within the short period of three months.—12-18-36.

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English ivy as a host of the citrus white flies was eliminated from California Quarantine Proclamation No. 10, while *Ixora* as a preferred host, and *Viburnum* as a casual host, were added, in a revision of the quarantine which became effective November 10, 1936.

Repellents for Japanese Beetle

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During the season of 1935 certain thiuram sulfides were found in laboratory experiments to act as repellents to the Japanese beetle, *Popillia japonica* Newm. (Guy 1936). Osburn (1934) has reported foliage protection from this insect by the use of a spray application of air-floated derris. A limited field experiment was undertaken in 1936, therefore, to compare the repellent action of derris (at 3 pounds) plus various stickers, tetramethyl thiuram disulfide and tetramethyl thiuram monosulfide (at 4 pounds) and hydrated lime (at 20 pounds per 100 gallons). The stickers used with derris were suggested by the work of Goodhue & Fleming (1936) with a rosin-residue emulsion. The relative effect of stickers upon the repellency of hydrated lime was also investigated. These stickers were menhaden fish oil, rosin-residue emulsion, and aluminum sulfate as recommended by Metzger & Lipp (1936). In addition, thiodiphenylamine (phenothiazine) was tested at 4 pounds per 100 gallons.

The experiment was conducted in a young orchard near Yorklyn, Dela. This orchard is a small rectangular planting including several varieties of apple and peach trees which had been severely injured by the Japanese beetle in 1935. For test purposes it was divided into 20-tree blocks containing an equal number of trees of each variety. All plots extended completely across the orchard. Three sprays, at 300 pounds pressure with a single-nozzle gun, were applied on July 2, July 16 and August 30. Good coverage was obtained with every material at the rate of 3.5 gallons per tree. None of them caused foliage injury. The first application was made before the Japanese beetle appeared in large numbers. When feeding became noticeable the additional coverage was provided.

Frequent examinations were made by both writers and by an impartial observer. The percentage of foliage destroyed by the beetles on all trees in each block was carefully estimated and the various treatments were thus compared.

Although this experiment was somewhat limited in size, definite indications of the degree of repellent action by the various materials were obtained. The best protection was afforded by tetramethyl thiuram disulfide plus 1 pint of a 40 per cent rosin-residue emulsion. Good results were given by certain other combinations, which, although of almost equal efficiency, may be rated in the following order:

Derris plus 3 pounds of rosin sticker No. 1 (50 per cent emulsion).

Tetramethyl thiuram monosulfide plus 1 pint of rosin-residue (40 per cent) emulsion.

Derris plus 3 pounds of rosin-residue (50 per cent) emulsion (Goodhue-Fleming formula).

Thiodiphenylamine plus 1 pint of rosin-residue (40 per cent) emulsion.

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Derris plus 3 pounds rosin-residue sticker No. 2 (50 per cent emulsion).

All of the mixtures of hydrated lime were inferior to these materials. The addition of 3 pounds of aluminum sulfate to hydrated lime gave greater foliage protection than the addition of either 3 pounds of rosin-residue emulsion or 1.5 pints of fish oil. Although the hydrated lime–fish-oil spray produced an unremovable residue on peaches, it was the least effective combination tested. All of the hydrated lime sprays were responsible for residues which rendered the early peaches unfit for market. The synthetic compounds and derris combinations, on the contrary, had the advantage of leaving no conspicuous residues; in fact, there was no indication at harvest of the sprays which had been applied. The results indicate that either tetramethyl thiuram disulfide or derris plus a rosin-type sticker offer considerable promise as Japanese beetle repellents.—12-18-36.

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Codling Moth Control with Lead Arsenate Substitutes

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Constant demand for lead arsenate substitutes has prompted a continuation of field tests with the more promising insecticides that afford protection against the codling moth and which offer possibilities of avoiding objectionable residue on the fruit at harvest. The materials considered in this paper are as follows:

Black Leaf 155-X—a nicotine–bentonite mixture containing 8 per cent nicotine and used at the rate of 5 pounds in 100 gallons.

Black Leaf 155-O—a nicotine–bentonite mixture containing 13 per cent nicotine. Three pounds were used in 100 gallons of water.

B. S. Fixator—made up largely of bentonite and containing no nicotine. Five pounds of the dry powder were used in 100 gallons of water to which was added three-fourths of a pint of nicotine sulfate when making up the spray. These three nicotine compounds are all products of the Tobacco By-Products and Chemical Corporation.

DX 67—a spray material containing 20 per cent nicotine in a specially prepared base. It was supplied by the Crop Protection Institute. In the first cover spray 3 pounds of lead arsenate were used with 1¾ pints of

[1] Approved Nov. 4, 1936, by Director of the N. Y. State Agricultural Experiment Station for publication as Journal paper 167.

DX 67. For the remainder of the season *DX 67* was used alone at the rate of 1 quart in 100 gallons.

Phenothiazine, supplied by the American Cyanamid and Chemical Corporation, was used in combination with soybean flour at the rate of 4 pounds of each in 100 gallons of water.

Basic zinc arsenate—a product of the General Chemical Company, was used at the rate of 3 pounds in 100 gallons.

Basic calcium arsenate—refers to a calcium arsenate prepared by G. W. Pearce of this station under conditions thought to produce mostly basic calcium arsenate. The soluble arsenic content was less than .75 per cent as determined by the method described in New York State Agricultural Experiment Station technical bulletin 234. It was used as a paste at a concentration equal to 3 pounds of dry powder in 100 gallons of water.

Cal-Rite—a calcium arsenate manufactured by the Niagara Sprayer and Chemical Company, Inc., was used at the rate of 3 pounds in 100 gallons.

Lead arsenate—a powdered acid lead arsenate, 3 pounds in 100 gallons, served as a basis for comparison of the efficiencies of the various insecticides tested.

Liberal amounts of spray material were applied in all cases, approximately 1 gallon of liquid per bushel of fruit per application. Skim-milk powder, one-half pound in 100 gallons, served as the spreader for the calcium arsenates applied on the Rhode Island Greenings. Soybean flour, 1 pound in 100 gallons, was used as the spreader in all other arsenical sprays.

All trees were sprayed with lime sulfur and lead arsenate at the delayed-dormant, pink and calyx periods. Five summer or cover sprays were made following the petal-fall application on Greenings. The Alexander, a large-growing variety, was sprayed at shorter intervals and received a total of six summer sprays. The first cover application was made on June 8 and the last on August 12. The Alexanders were picked September 2 and the Greenings September 15.

Table 1 lists the summer spray treatments, the figures expressing codling moth control and amounts of spray residue on the picked fruit.

Discussion.—The season of 1936 was extremely dry, drought conditions commencing in June and continuing until the last of August. During July temperatures between 100 and 107° F were experienced for as many as four consecutive days, and wherever sulfur spray residue was present on the trees during the periods of extreme heat serious injury resulted to both fruit and foliage. In this connection it should be noted that unsprayed trees and those treated with copper fungicides remained practically free of such injury.

The sulfur burn on fruit and foliage made it difficult to detect any minor injury caused by the several insecticides. With the exception of the plots treated with calcium arsenate, no important injury developed. About the time that drought conditions were relieved by occasional showers arsenical injury became noticeable, and by the middle of October the more severely injured trees had lost considerable foliage. At

Table 1, Part I.—Codling moth control with lead arsenate substitutes, 1936.*

Plot No.	Summer Spray Treatments	Variety	No. Apples Counted	No. Stings on 100 Apples	No. Worms in 100 Apples	Per Cent Efficiency Based on Worm-infested Fruit	Residue on Picked Fruit	
							Arsenic	Lead
1	*Black Leaf 155-X* 5 lbs.	Alexander	3986	1.6	12.1	87.2	Below tolerance	
2	*Black Leaf 155-O* 3 lbs.	Alexander	3669	1.9	17.1	81.9		
3	*B. S. Fixator* 5 lbs., nicotine sulfate ¾ pt.	Alexander	3172	.9	4.5	95.2		
4	*DX 67* 1 qt.	Alexander	4291	2.5	14.4	84.8		
5	Phenothiazine 4 lbs., soybean flour 4 lbs.	Alexander	2549	1.4	8.9	90.6		
6	Basic zinc arsenate 3 lbs., hydrated lime 2 lbs.	Alexander	3172	7.9	8.5	91.	.100	.011
7	*Cal-Rite* 3 lbs.	Alexander	1541	11.6	8.4	91.1	.110	.011
8	*Cal-Rite* 3 lbs., hydrated lime 3 lbs.	Alexander	1873	10.9	17.7	81.3	.097	.010
9	*Cal-Rite* 3 lbs., hydrated lime 9 lbs.	Alexander	1666	4.2	20.4	78.4	.086	.007
10	*Cal-Rite* 3 lbs.	R. I. Greening	861	75.8	38.2	73.1	.052	.007
11	*Cal-Rite* 3 lbs., hydrated lime 3 lbs.	R. I. Greening	1148	45.3	66.	53.5	.046	.007
12	*Cal-Rite* 3 lbs., hydrated lime 9 lbs.	R. I. Greening	1371	15.8	46.5	67.2	.047	.007
13	Basic calcium arsenate 3 lbs.	Alexander	2087	5.9	4.0	95.8	.106	.005

* Amounts mentioned for 100 gallons. All plots received lead arsenate in the petal-fall application.

Table 1, Part II.—Codling moth control with lead arsenate substitutes, 1936.*

Plot No.	Summer Spray Treatments	Variety	No. Apples Counted	No. Stings on 100 Apples	No. Worms in 100 Apples	Per Cent Efficiency Based on Worm-infested Fruit	Residue on Picked Fruit	
							Arsenic	Lead
14	Basic calcium arsenate 3 lbs., hydrated lime 3 lbs.	Alexander	1034	3.	3.1	96.7	.136	.005
15	Basic calcium arsenate 3 lbs., hydrated lime 9 lbs.	Alexander	3016	5.8	6.3	93.3	.108	.005
16	Basic calcium arsenate 3 lbs.	R. I. Greening	1326	47.1	6.6	95.3	.068	.005
17	Basic calcium arsenate 3 lbs., hydrated lime 3 lbs.	R. I. Greening	1301	21.7	3.6	97.5	.083	.004
18	Basic calcium arsenate 3 lbs., hydrated lime 9 lbs.	R. I. Greening	590	30.3	3.1	97.8	.080	.005
19	Lead arsenate 3 lbs., hydrated lime 2 lbs.	Alexander	4387	2.1	.8	99.2	.096	.192
20	Lead arsenate 3 lbs., hydrated lime 2 lbs.	R. I. Greening	3202	20.9	4.9	96.5	.078	.158
21	Check, no spray after calyx application	Alexander	2211	.6	94.5			
22	Check, no spray after calyx application	R. I. Greening	1292	1.	141.8			

* Amounts mentioned for 100 gallons. All plots received lead arsenate in the petal-fall application.

that time plots 13 and 16, that had been sprayed with basic calcium arsenate, were practically defoliated; plots 14 and 17 had lost close to half their leaves; plots 15 and 18 showed not more than 10 per cent leaf drop. Plots 7 and 10, sprayed with *Cal-Rite*, were about 50 per cent defoliated, but not more than 5 to 10 per cent of the foliage fell from plots 8, 9, 11 and 12.

As a result of the first field tests made with this new calcium arsenate it appears that a very marked improvement has been made in the insecticidal efficiency of this arsenical as compared with one of the commercial brands. The spray gave excellent coverage, and the residue was removed without difficulty in a flotation washer. It should be remembered, however, that the material had the advantage of being in the paste form and the tests were made under drouth conditions. As already mentioned, the basic calcium arsenate was considerably more toxic to the foliage than the commercial brand. However, hydrated lime used at the rate of 3 pounds for each pound of the arsenical proved a very efficient corrective.

Of the four nicotine sprays tested, the tank-mixed spray made of *B. S. Fixator* and nicotine sulfate gave the best results, namely 95.2 per cent efficiency against the codling moth as compared with 99.2 per cent secured with lead arsenate. No objectionable residue was left on the picked fruit from any of the nicotine sprays. The principal objection is their high cost. However, many growers are willing to pay comparatively high prices for materials that will control codling moth and do not require cleaning of the fruit.

Phenothiazine used in all six cover sprays gave an efficiency of 90.6 per cent against the codling moth and no injury was noticed on either fruit or foliage. The main objection to this material was the dull appearance of the fruit resulting from the dark-colored and dirty-looking residue.

Applications of basic zinc arsenate left an even film of spray residue not unlike that produced with lead arsenate. No injurious results were observed during the season and the efficiency rating against codling moth was 91 per cent.

Conclusion.—Although lead arsenate continues to offer the most economical and effective control for the codling moth, there are growers who are willing to incur considerable expense for insecticides that do not leave objectionable residues on the fruit. Unfortunately, many growers have experienced substantial losses by placing too much dependence in untried materials that have proved of little value. Of the substitutes now available that offer ways to avoid a residue problem, calcium arsenate used judiciously and certain of the fixed nicotine sprays have met with most success in New York state.—11-30-36.

THE MONTANA quarantine relating to the potato tuber moth, issued September 21, 1936, requires as a condition of certification, either (1) inspection of the field, and of the potatoes when ready for shipment, or (2) fumigation of the potatoes. The quarantine applies to shipments from California, Florida, Hawaii, Texas, Utah and Virginia.

Problems in Termite Control

DONALD M. MUIRHEAD, *Duxbury, Mass.*

Full credit for the types of successful control which we are about to discuss belongs to that group of entomologists, who, after years of careful research, have given us a very definite pattern to follow. I know myself to be singularly fortunate in having not only access to this knowledge which they have gleaned, but also the benefits of constructive criticisms from many of them during their inspection of the actual field work.

Termite infestation has occurred in practically all types of building construction and each type offers its particular control problems. For this reason I have selected for discussion problems which have occurred in six types of construction.

Brick office building.—A brick office building had a very severe attack. A sawmill had occupied the site originally, was razed, and considerable fill was placed on this site to bring the land to the desired level. The termite infestation in the soil was indicated by the destruction of the bottom of wooden kegs stored on the ground for less than one month.

The foundation of the building consisted of concrete piling and reinforced concrete beams. A cinder fill was used to bring the inside grade up to the top of the concrete beams, or approximately 2 feet above outside grade. A concrete slab was then poured over the entire area. In the main entrance hall and hospital room this concrete was covered with tile; in the office rooms a 1-inch granolithic cement finish had been used. The exterior walls were of brick and hollow tile, the interior partitions of wood studs with wire lath and plaster. The second floor system consisted of steel beams supported on exterior walls and H-columns with 3-inch wood plank flooring finished with oak and maple flooring.

The manager's office on the second floor gave the first evidence of attack. Large sections of the finish oak floor had been eaten and a rug near the desk had given way where termites had destroyed the backing. Poisoning of the soil, and protection of the wood in the partitions and second floor by preservative injections was tried but in the following spring there was appreciable increase in destruction in these same places and outbreaks in other areas.

The building was comparatively new and, in addition, played an important part in the functioning of the corporation. It was decided, therefore, that permanent control should be used. The first step was to determine the extent of damage and source of infestation. The base, lath and plaster were removed on one side of each of the stud partitions on the first floor. This exposed the wood shoe, which was laid directly on the concrete slab (resting on the cinder fill), and the lower end of the studs. Every interior partition was found to have active attack in progress. In many cases termites had followed up these studs, particularly the ones which abutted the exterior walls, and had established colonies on the second floor. It was also found that the termites had built tubes in the hollow tile and brick work of the exterior walls to the second floor.

It was decided that a metal shield should be used through the exterior walls and that this shield should continue around the entire building. This shield was to be introduced at a level which corresponded on the exterior to the course of face brick above the cast-stone water table and on the interior it would come through the wall at the approximate level of the base. This was below the level of all wood in the main building except the wood baseboard used in certain offices. These, together with their wooden grounds, or nailing strips, were to be removed and a concrete base substituted.

It was important that this work be done with a minimum of interference to the working force, therefore all cutting of masonry and rough work had to be carried on at night.

Second floor loads and exterior wall loads were calculated and adequate shoring put in place. The face brick in the exterior wall was expensive and only a limited quantity of the same color range available. Special chisels were made to correspond in width to the exact height of the brick so that neither the course above or below would be injured, and these chisels were operated in the common type of rivetting hammer. In this manner, the single course of brickwork was removed in sections and a single course of 8-inch hollow tile broken out on the inside of the wall.

The metal shield was made up of 24-ounce cold-rolled copper upon which lead had been electrolytically deposited. A slip was used at all joints in the shielding which would allow for one-half inch settlement or expansion in every 8 lineal feet of wall. The 45-degree angles which the shielding formed with the faces of the wall were broken on a metal break to secure straight true lines and efficient joints. When the shielding was in proper position, the openings were bricked up and small steel wedges were driven in the mortar between the bricks to guard against settlement due to shrinkage or compression of the mortar. This procedure was followed around the entire building.

The interior partitions were supported and the lower 6 inches cut off. The wood shoe and 4 inches of studding were removed and a concrete curb 4 inches high and 6 inches wide was poured in place. This curb was coved at the intersection with the floor and bullnosed at the top for sanitary reasons. To guard against shrinkage or settlement cracks in this curb, which would provide termites with means of access in future, a copper shield was placed on top of it. Where the curb abutted the exterior wall this shield was tied into the main shield of the exterior wall, to provide a continuous physical barrier.

H-columns in the partitions and soil pipes in pier corners presented another difficulty. Modifications of the double cone were finally evolved and mixture of creosote oil and tar was used in the upper cones or boxes.

The work required three months to execute and cost approximately $18,000.

Stone residence.—At an attack on a stone residence termites were found to be coming through the stone wall below grade at a high portion of the site where the first floor joists were below exterior grade. This portion of the wall was blanketed with shrubbery and was continually

damp. Obviously a shield which had to start below the joist level could be run into the wall not less than the bearing of these joists and would then have to turn up in the wall vertically 8 inches before it would be possible to bring the shield out above grade on the exterior. This would have been very costly and necessitated the cutting out and replacing of a great amount of faced stone. Therefore, a trench 12 inches deep was dug adjacent to the wall and the earth supported with a stone curb which matched the house. This enabled the rough stone of the foundation to be removed instead of the face stone of the wall and furnished a straight line for the metal shielding. The trench bottom was graded to a dry well and the replaced foundation was laid in cement mortar.

Brick hospital building.—A brick hospital building was found to have a very severe termite attack. The soil infestation was so severe that one of our entomologists remarked that when he dropped a match after lighting his pipe, termites were after it before it was cold. There may be some slight exaggeration in that statement but I do know that timber for shoring, stacked on the ground, was attacked in less than a week.

Interior wood partitions in this building had evidently been put in place before the basement floor was poured and termites had made the most of it. The particular problem, however, was due to construction. The basement walls were of concrete up to a point 8 inches above grade. The basement windows had been set on this line and the walls were solid brick from that point up. The interior face of these walls had been furred with wood furring, then lathed and plastered. A shield run through at the top of the concrete section would still leave these wood furring strips open to attack through settlement cracks in the wall and through the construction joint between the concrete floor and the wall. Therefore, it was decided to remove this wood furring from the floor level up to the height of the concrete wall and substitute metal furring and lath in all areas below the shield level. As the work progressed, the wisdom of this determination became apparent. Wood blocks had been poured with the concrete to serve as nailing blocks for the furring and in several cases the wood spreaders used in the forms had not been removed. Termites were present in these spreaders and blocks, and destruction of the furring on the walls had started.

Wooden frame houses.—In connection with this work, the hospital had several wooden frame houses which were in various stages of decay and due to be razed when the future permanent buildings, which had been planned, were erected. A definite time for this new building had not been established but it was felt that five years of useful life of the present wooden houses, which housed members of the hospital staff and employees, would be ample.

These houses were heated from the central heating plant but old wood coal bins and partitions had been left in place. All of the houses had wooden basement window frames and wooden steps in direct contact with the soil. For the most part, termite destruction was occurring in these places and had not affected the structural timbers. In this case it was felt that temporary inexpensive methods only were justified and that the average expenditure should not exceed $200 per house.

The first step was the removal of wood in actual contact with the soil. The lower wooden step on all exterior stairs was removed and a concrete step substituted. The lattice work of the porches was cut off 4 inches above grade, old wood basement partitions removed and steel basement sash substituted for the old wooden ones. Additional ventilation was secured through these steps which was also helpful. Soil poisoning was then used around the exterior of each house.

While it is true that signs of activity have since been observed, we feel that the desired result, that is the prevention of serious structural damage for the next five years, will be approached if not actually accomplished in most of these houses.

Typical good residence structure.—One other house furnishes several problems which are usually encountered on the typical residence of the better class. The foundation was of stone in some sections and of concrete in others. Very few voids occurred in the stone work and the materials were the best of their respective class. It was quite certain that termites had not been encouraged by faulty workmanship or materials. Nevertheless, this residence had been damaged to the extent where approximately $2500 was needed for repair work without any consideration given to control of future attack.

The attack started where so many attacks start, at filled porches and paved terraces. Where terraces and porches are concerned, the height of the main foundation above grade does not appreciably lessen the danger from termite attack. The surface of these porches and terraces is usually just one comfortable step from 4 to 8 inches below the finish first-floor grade. Where then are the sill and joist ends in relation to the fill under these filled areas?

The 6 inches from the finish floor to the porch surface will represent 2 inches for finish and rough flooring and leaves only 4 inches for sill and joist. It will be found that the average for sill and joist is 10 to 12 inches, and assuming the concrete, brick or bluestone paving of the filled area to be 4 inches, this places the bottom of the sill or joist at least 2 inches below the paving. If, as in some cases, the two are on the same level, we still have an ideal place for termite attack. In most cases we have found the fill in these porches to contain wood scraps which have furnished ideal breeding places or focal points of trouble. Even if treated sills are used at this point, the studding, ends and rough exterior boarding are still open to attack.

The type of shielding used here has been that which starts at the surface of the porch about an inch beyond all woodwork, runs horizontally to the rough boardings and is then carried up behind the clapboard or shingle to form a weather stop, then downward to the bottom of the sill and joist, in through the wall and projects beyond the interior face and forms a 45-degree angle with it.

Danger spots of this sort occur in almost every home and at these points it should be remembered that even if the sill were of concrete, termites would still have a hidden access to the wood above. From observation and experience with this condition I believe firmly that a physical barrier which will not crack or deteriorate is necessary.

I should state that wherever metal shields are used they should be formed with straight true lines, efficient joints with allowance for settlement and expansion, and intelligently placed. Failures are bound to occur if the work is not properly designed and executed.

There is still much research to be done before many pertinent questions can be answered. I have had the opportunity to conduct some tests with termite colonies in glass jars and the results have been interesting. The possibilities of experimentation with termites in glass containers, however, is limited, due to the restricted area. Shortly I expect to use a large pit where temperature and humidity can be controlled for 12 months of the year. With this it may be possible to get light on some of the questions.

Structure with brick-walled basement.—Capillary attraction of moisture has been observed in all concrete, brick and stone walls or piers. An interior brick basement wall 24 inches thick and 12 feet high has brought the danger of moisture through capillary attraction very forcibly to my attention. The footing of this wall was in damp earth; the wall itself extended only to the first floor of the building, where a 5-inch reinforced concrete slab crossed the top. Linoleum has been cemented to the concrete slab and a strip of the linoleum, approximately 5 feet wide and running the full length of the wall below, had become loosened and swollen. Upon removal, considerable moisture was found and the concrete slab was wet through. This dampness was the result of capillary attraction through the 12 feet of brick wall, although the faces of the wall were apparently dry.

The rate of evaporation in the surface of the wall exceeded the rate of capillary action and the moisture here was dissipated. Where the concrete slab and linoleum crossed the top of the wall, however, the rate of evaporation was much lower than the rate of capillary action. The result was a growing accumulation of moisture. I believe this condition illustrates the reason for certain termite activity which at first glance may seem illogical and without order. Careful investigation will usually disclose that the areas of intensive activity are at or adjacent to areas where the capillary action is greater than the rate of evaporation—in other words, where ventilation is poor.

Experiments with sections of concrete and other types of masonry walls or piers where the moisture content of the soil is predetermined should prove interesting. How large a colony could thrive on moisture obtained in this manner? What leaching effect, if any, would this moisture have on various toxic materials with which the wood might be impregnated?

Time does not permit the discussion of the many other interesting experiments which might prove helpful but I believe that, given the help of these men who have already done so much in this field, our experiments may throw some further light on the mechanics of termite control and its ramifications.

I wish again to acknowledge my indebtedness to these entomologists and to express the hope that their good work will continue for many long years.—11-30-36.

Termite Control in Northeastern United States

GEORGE E. SANDERS, *New York City*

It is now almost five years since the continent-wide increase in termite population was first noticed in this area. The reason for the increase is still unaccounted for. We find no worth-while enemies of the termite working here. We have no record of increases or decreases in termite population in history, and so no one can predict the duration of the termite outbreak or its intensity. We do know that since 1932, calls from property owners reporting termites have ayproximately doubled each year over the preceding one.

The damage to buildings in this area varies from nothing to as much as $25,000 in a single building. In the majority of cases the trouble is identified before much damage is done. We often have to replace floor girders, floorings, door jambs, surbase, wooden floor supports, etc. We have found wooden floors laid on cinder fill that we could remove easily with our hands and plenty of wood that we could crush with our hands on account of termite damage. Only two weeks ago, we were called in by a manufacturer of office equipment to treat his plant, a solid steel and concrete building, for termites. Evidently they were feeding on some wood used as fill under the cement basement floor and had come up through cracks in the cement and eaten the legs off one of his new desks stored in a crate in the basement.

Although the termite is most common in suburban areas, it is often present in the centers of towns. We have found them in two places in the Metropolitan Museum of Art. They are damaging the buildings on three of the four corners at 60th street and Lexington avenue, only 25 blocks from here, and we have found them damaging the record books in the lower vault of a bank in Wall street. In the apartment houses of the Bronx and upper Manhattan, we find termites very numerous, attacking the flooring which, in the lower apartments, is usually laid on cinder fill. A few weeks ago we inspected the public library at Cambridge, Mass. A number of window casings are being eaten by the termites, and termites are coming through the cement floor in the stack room and feeding on the shelving and books. The library authorities are now getting bids from private concerns to eliminate the termites.

Regarding termite control, the ideal method, we all realize, is to insert a sheet of non-corrosive metal, such as copper, between the foundation and the wooden portion of the building. We recently placed a sheet of 16-gauge copper on a foundation for a customer. The house was approximately 30 by 40 feet. The actual cost was around $175. We feel certain that the house will never be attacked by termites. In this case, we had to change our methods as the work progressed because the builder had modified the architect's plans. Builders, in our experience, seldom follow architect's plans in detail, and termite-proofing a building in the process of erection must be closely supervised by someone well acquainted with the habits of termites.

We are in favor of the copper shield in all cases in new buildings. In buildings already completed we believe that the copper shield is in most cases impractical, because it is too expensive to install in old buildings, and because it is in many cases impossible to place it in an old building to secure 100 per cent effectiveness. In old buildings we favor chemical soil treatments or a combination of chemical soil treatments and copper shielding. We do not depend on either wood impregnation alone or the use of a single preparation for soil poisoning. We may have a great deal to learn about these methods.

In our termite work, we first thought of the termite present here as an insect nesting in the earth and taking soil moisture into its system frequently. Then we thought of the various chemicals that we could use that would poison the soil moisture best and over the longest period, with the greatest safety to vegetation and animal life. We finally settled on two basic poisons, the chemistry of which we thoroughly understand. These two poisons we can change and modify, so as to make them from 99 per cent insoluble, and so long lasting, to 100 per cent water soluble and so immediately active and temporary in action. We buy only raw materials and make all of the combinations indicated as the work is in progress. We do not believe that any one chemical can be depended upon for proper soil treatment. In one situation where there is excessive leaching, a very insoluble combination may be needed; in another, where there is no leaching, a highly soluble combination should be used; in locations where there is danger of gases, a fungicide must be combined with the poison, and so on. We frequently use five or six different combinations on one job, placing each with reference to leaching, danger to vegetation, etc. We are so convinced of the permanency of proper chemicals so placed, that last spring we increased our guarantee from five years to 10 years.

In good termite work complete elimination is not in all cases accomplished on the first treatment. However, several concerns, as well as ourselves, get complete elimination in from five out of six to nine out of 10 infestations on the first operation. With but minor differences, we use the same methods. In treating, we like to use only relatively permanent materials on the first operation, when, if the termites are completely eliminated, we are sure of a good long-lasting treatment. We could easily increase the percentage of complete eliminations on the first operation by using more active but less permanent materials, but there is the matter of a 10-year guarantee that, with such temporary materials, would be jeopardized.

The charges of the better concerns on termite work are very reasonable when you consider the expenses outside of labor and materials, such as rent, printing, telephone, advertising, sales cost, inspection costs, various insurances, public liability, property damage, workmen's compensation, etc., together with three or four idle months when the organization must be kept together while overhead goes on with little or no income. Another item to be considered is the high cost of materials that can be relied upon as being permanent, that can be used under floors laid directly on 2-by-4's and they on cinder fill, without danger of

warping the floor, and that are free from obnoxious odors. Such materials are, in our opinion, necessary for the most efficient and long-lasting control of termites in floors laid directly on cinder fill or "nail-crete," which we find so common in schools and in the larger apartment houses.

We find that many firms are learning more about termites, and the public is gradually learning more about termite operators, and gradually better work is being done, and incompetent operators being eliminated from the field. Points that customers are becoming more insistent on are neatness in the work, safety to vegetation, absence of strong odors and the minimum destruction possible. As time goes on we find that people are coming to realize that termites can be quickly and completely eliminated and the premises made termite proof for a long period, with, in most cases, practically no danger to vegetation, no odors, and no publicity or general disruption inside the house, warning the neighbors that termites are present. This gives some idea of the lines that we are following, and which we have found have given us satisfied customers. —12-24-36.

Relation of State Workers to Commercial Termite Control Companies

NEELY TURNER, *New Haven, Conn.*

The eastern subterranean termite, *Reticulitermes flavipes* Kollar, was recognized as a pest of buildings in Connecticut as early as 1909. The published records of the Connecticut Agricultural Experiment Station contain several references to termite damage between 1909 and 1931. Since 1931, reports of termite damage have increased greatly and it has become an established fact that this insect is causing much damage in all sections of the state. In 1931 we knew of no termite control companies operating in the state, and all of the termite control work at that time was carried on by carpenters and builders. However, in the past two or three years several companies have been operating solely for the purpose of termite control. Some of these concerns have used construction methods advocated by the U. S. Department of Agriculture and others have used chemical treatments.

The Connecticut Agricultural Experiment Station has the duty of establishing and publishing facts about insect biology and control through independent research and from published records of other investigators. In the case of termite control it is necessary to conduct tests over a long period of years in order to obtain adequate information. Therefore we have relied almost entirely on published records in obtaining information on termite control. At the same time we have of course started our own tests and observations and have at this date many facts confirming the conclusions of others. We have had the opportunity of seeing many infested buildings protected by means of construction methods, in-

cluding the use of metal termite shields. We have seen failures from poor and improperly applied construction methods, and from poor and improperly applied chemical treatments.

We have followed consistently the recommendations of the federal Bureau of Entomology. About two years ago we began to receive calls from salesmen representing chemical treating concerns. These gentlemen informed us very confidently that metal termite shields would not protect buildings from termites. They stated that termites can and do cross termite shields, and that photographs exist proving this to be a fact. Although we had at hand Dr. Snyder's published statement that termites have never been known to construct tubes *up over* properly installed shields, we immediately investigated the entire matter. A summary of our findings was published in Connecticut Agricultural Experiment Station Bulletin 382, issued in March 1936. The earliest reference that we found to the use of the metal shielding principle was made in Australia in 1905. The only statement there in regard to the failure of shields was that the tin rusted and broke down and allowed termite entry. In all the scientific literature published since that time I have been unable to find a single statement creating any doubt as to the efficacy of metal shielding. Dr. Snyder (1935) states: "So far as we can determine from correspondence all over the world, we have no record of a metal termite shield, properly installed, that has failed."

In our own experience we have seen shields installed in nearly all types of buildings, most of which were very heavily infested before shielding. In some of these buildings termites have made repeated efforts to enter. There has been no indication of shield failure due to re-entry of termites from the ground in any of these buildings. We have seen termites cross *from above* a newly installed shield. In fact, in one heavily infested house termites dropped tubes over the shield in four places within a month after installation. Three crossings were made because of imperfections in shield construction, and one hanging tube made a soil contact. The hanging tube was broken off by us and was not rebuilt. Slight shield alterations have apparently corrected the trouble in the other places. There is no doubt that termites can cross down over a shield if they have an adequate moisture supply. This does not mean that they can *tube up over* a shield or that a shield is useless.

We have also inspected one building, located in Manchester, Conn., in which shields were supposed to have failed. Although some sheet metal was used in the foundations, there was no metal termite shield within the specifications for construction of such a shield. In fact, in one place the metal was placed *above* the infested wood floor which rested on the ground.

To the best of my knowledge, all of the information regarding the failure of metal shields is contained in three photographs. I have seen a print of one of these, a reproduction of the second in an advertisement in a journal, and the third has been described in detail by a home owner who saw it. *Not one of these three photographs proves that properly installed metal termite shields are ineffective.* One of them was taken in a building in which only one end was shielded. It is too much to expect this small

section of shield to protect an entire building. Another is obviously a laboratory picture which shows a tube on a shield, but of course is taken from such an angle that the under side of the shield cannot be seen. The third, recently published in an advertisement in a trade journal, shows a piece of crumpled tin above a post with a termite tube on the metal. It, too, avoids a picture of the under surface of the tin, but there is no doubt in my own mind that termites could cross it. However, by no stretch of the imagination is a piece of crumpled tin a metal termite shield.

Now let us look at the record of attempts to control termites by chemicals alone. The Australian paper noted above suggested the use of a "preserving oil" containing arsenic and the use of common table salt as a soil treatment. It also states that fumigation is of no practical value and that poison baits may reduce the numbers of termites. The literature published since that time is full of references to these and other chemical treatments. Of this body of literature, Randall & Doody (Kofoid 1934) have stated: "Numerous materials and methods have been recommended for this purpose by various persons and in various regions. For no one method or material, however, is there available any satisfactory body of experimental data or field observations, nor is any one of them accepted practice. Indeed, these recommended methods have been abandoned by their authors in several instances, at least, in favor of control by construction methods, because of the lack of authentic information as to the effectiveness of such treatments, as well as on account of the health hazards and other unfavorable features involved in the use of the more widely advocated materials and methods." Snyder (1933) has repeatedly stated, "The use of such soil poisons is, however, still very much in the experimental stage and on present information cannot be recommended as a permanent remedy." He has also stated: "Due to the extent of the possible ramifications of termites in a building which has been infested for some little time and the protection which they have in their burrows concealed in the wood, no control worth while by fumigation or spraying has proved to be possible, and spraying, even if applied under strong pressure at borings made at occasional points in eaten timbers, is unsatisfactory."

So far as I know, all of the actual service records of chemical treatments by highly organized companies are in the hands of these companies. As long as this information is withheld it is impossible to pass any judgment on the work done by them during the past five or 10 years. We are entirely open minded on the subject and would welcome any proved facts demonstrating the value of chemical treatments. We have repeatedly invited chemical treating concerns to let us examine infested buildings before and during treatment, and at specified intervals after treatment, in order to see for ourselves just how effective the treatment is. So far only one operator, George Sanders, has shown any inclination to do this.

The advertising and sales methods of many companies operating in Connecticut are open to question and in some cases to criticism. The following list of statements and practices is a summary not taken from

any one concern, but all found in literature and sales letters distributed in Connecticut.

1. That termite queens deposit 80,000 eggs a day.
2. That colonies can be controlled by killing the queen.
3. That termite treatments are guaranteed. I have not found a single concern willing to guarantee to kill all the termites and prevent further damage.
4. The sales argument that houses are damaged very rapidly and repairs must be made quickly.
5. The not-infrequent diagnosis of termite damage when no termites are present, caused by employment of incompetent inspectors. One libel suit is now pending in Connecticut as a result of such a report.
6. The not-infrequent quoting of U. S. government literature in advertisements, apparently done to give a hint of government approval, when no such approval exists.
7. The listing of government buildings as treated, accompanied by statements of salesmen who say the government prefers chemical treatment to U. S. Department of Agriculture recommendations. The fact that any government building is treated with chemicals is no proof that Dr. Snyder's recommendations are worthless.
8. The repeated statement, usually contained in high-pressure sales letters, that buildings have to be "jacked up" for shield installation and that shields cannot be installed in existing brick buildings. This shows a profound ignorance of construction methods.
9. The publication of pictures of massive stone buildings with the statement that they have been "undermined" by termites. Termites eat wood in buildings, they do not undermine them.

While none of these are major criticisms, they certainly do not represent a conservative policy based on facts.

The fire and health hazards accompanying the use of chemicals for termite treatments deserves consideration. In our termite bulletin we called attention to the fact that some materials for wood treatment contain a more or less inflammable solvent, the use of which constitutes a fire hazard. We did not even mention carbon disulfide as a temporary soil treatment because it is so inflammable. A recent publication of the American Fire Insurance and Indemnity Group calls attention to these fire hazards. The health hazards of chemical treatments are less definite. The California Termite Investigations Committee has been outspoken against the use of arsenic in any form. This point is highly controversial but the little evidence available does show that the use of water-soluble arsenic is open to serious objections. The fumes from several wood-treating materials are objectionable if not actually dangerous. Crude creosote is very undesirable for treatment of timber in place in a building. Preparations containing orthodichlorobenzene have been used by commercial operators with little regard to the poisonous qualities of the fumes in a confined space.

Entomologists employed by state and federal governments must at all times be impartial and unbiased in their decisions. In the face of the evidence it is difficult to be very enthusiastic about chemical treatments

for termite control. It is even more difficult to look very favorably on any company whose chief sales argument is a campaign against metal shields. I personally know of three infested buildings in Connecticut treated with chemicals by reputable commercial concerns, in which termites are still active. I am sure that no entomologist or engineer can have the slightest objection to the use of chemical treatments for termite control, provided these materials are sold for what they are and not as the perfect cure necessary because the recommendations of scientists are held to be without value.

On the basis of our own experience in Connecticut, which includes many re-examinations of shielded buildings, we can definitely support Dr. Snyder's statement that termites cannot come up over a properly installed metal shield. Until this has been definitely disproved, we will stand with Snyder and St. George of the U. S. Department of Agriculture; von Schrenck of St. Louis; Light, Randall and White of the California Agricultural Experiment Station; Kofoid and the California Termite Investigations Committee; and dozens of other impartial investigators both in this and foreign countries, all of whom have published definite statements upholding this attitude. We await definite proof of the effectiveness of chemical treatments.—12-24-36.

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Studies on the Larvae of the Native Elm Bark Beetle

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In the course of our investigations on the life history of the native elm bark beetle, *Hylurgopinus rufipes* (Eichhoff), some interesting facts have come to light. Because scolytid larvae are relatively inaccessible, and their activities cannot normally be readily observed, exact information about their growth rate is rare. In this paper we report, first, the determination of the number of larval instars by the method of measuring head capsules, and second, some direct observations by a method to be described below.

At first we attempted to ascertain the number of larval instars by measuring the head widths of mixed lots of larvae taken at random from various localities in the field. This method has been successfully used by Blackman (1915) on *Pityogenes hopkinsi* Swaine, by Prebble (1933) on *Ips pini* Say, *Pityokteines sparsus* Leconte and *Dendroctonus simplex* Lec., and by Bedard (1933) on *D. pseudotsugae* Hopkins. In all of these

[1] The authors are indebted to Dr. R. B. Friend, under whose direction this work was done, for a critical review of the manuscript.

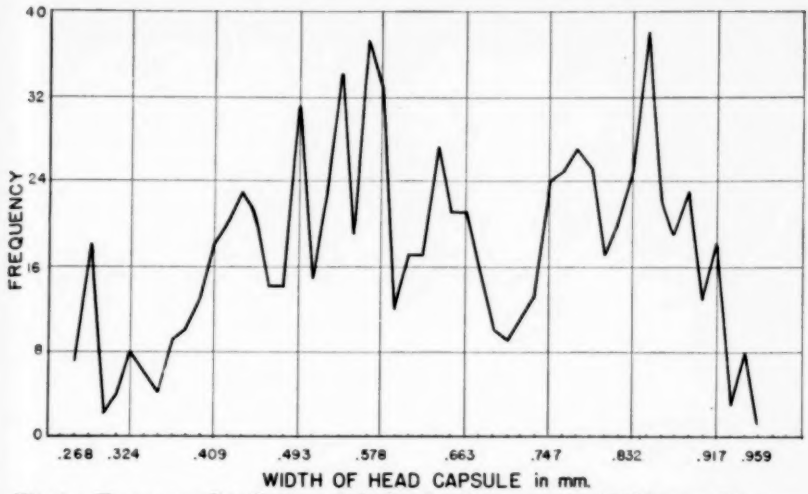

Fig. 1.—Frequency distribution of the head measurements of 853 larvae. These are mixed lots taken at random from various localities in the field. Each division on the abscissa equals .014 mm.

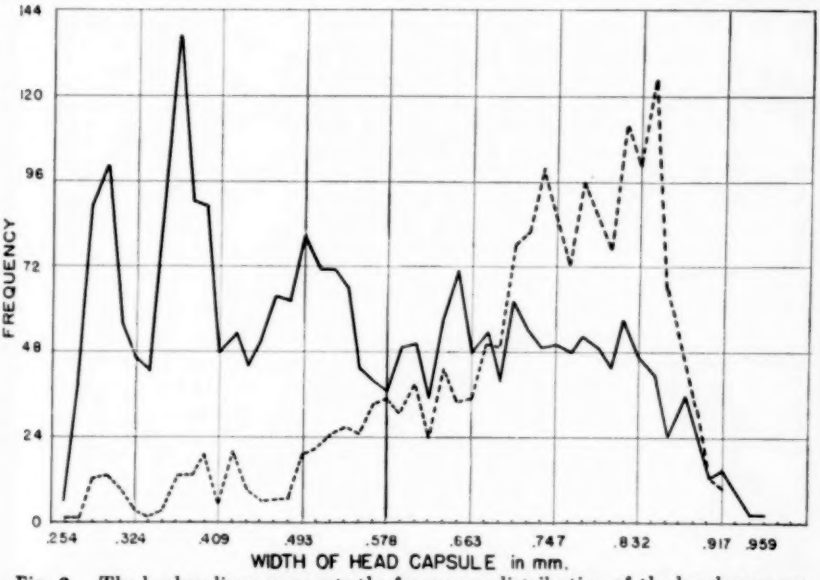

Fig. 2.—The broken line represents the frequency distribution of the head measurements of 1816 larvae from a single tree. The solid line represents 2598 larvae, the aggregate of those collected as single families.

the measurements fell into distinct groups so that the number of instars was clearly indicated.

Larvae preserved in 70 per cent alcohol were measured to the nearest division of an ocular micrometer. They ranged from 19 to 68 units, or, as one division equals .014 mm., from .268 to .959 mm. The series of measurements of 863 larvae collected during the first season (1934) is shown in fig. 1. There are no distinct groups, for some larvae occur at every interval. The first peak is definitely known to represent the first instar, for many of these measurements were made upon larvae which had just hatched from the egg. From measurements made on specimens in the prepupal period it is known that the peak starting at about .817 mm. and all higher than this definitely refer to the last instar. But the other peaks occur so irregularly that it is impossible to determine the number of instars between the first and last.

It was thought that perhaps a sample from a more restricted and uniform environment would give a clearer picture. Accordingly, during the second season (1935) 1816 larvae from a single tree were measured. The

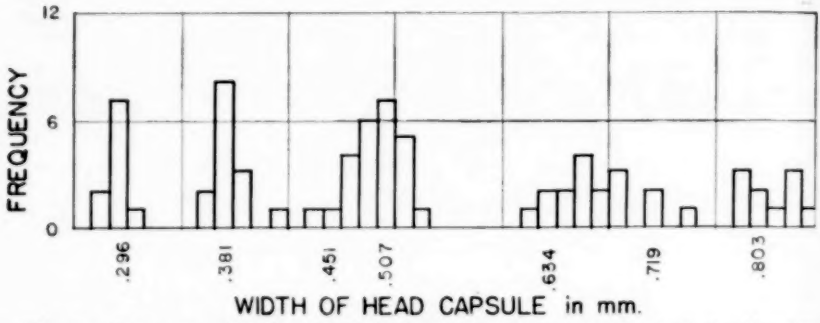

Fig. 3.—Frequency distribution of the head measurements of a single family of 75 larvae.

broken line in fig. 2 represents this series. There is, unfortunately, a scarcity of younger larvae, though the position of the first instar is sufficiently clear. As in the preceding figure, the position of the last instar is also clear, occurring in about the same place. Leaving out of consideration the lower instars, because of insufficient material, it is still impossible to demarcate the penultimate and antepenultimate instars in which most of the larvae fall.

During the third season (1936) it was decided to collect larvae by single families and plot each family separately. The ideal situation to encounter here is a family containing many larvae, with some in each instar. Fig. 3 shows a histogram of a family of 75 larvae, one of the largest. Here can be seen distinct groups indicating the presence of five instars. Many other families showed a similar frequency distribution. On the other hand, there were a number, which, though not containing individuals from all the instars, showed three or four groups of measurements arranged so as to indicate a total of six instars. In these the instars I and II occurred approximately as in the five-instar families. Moreover, the widths in the sixth or last instar were about the same as those of the

last instar in the five-instar families. If all the families, totalling 2598 larvae, are plotted together we get a curve represented by the solid line in fig. 2. There is no doubt about instars I and II, but the remaining instars are difficult to delimit. When the two sets of larvae are mixed, as they might be in collections made at random, one might guess that there were possibly eight instars, a number which never occurred when individual families were plotted separately. This is a situation analogous

Table 1.—Comparison of actual mean head widths with the theoretical figures obtained by using a growth ratio.

Instar	Variation mm.	Actual Mean mm.	Growth Ratio	Theoretical Mean	
	Five-instar Families			*If Ratio=1.322*	*If Ratio=1.303*
I	.254–.324	.286 ± .010		.286*	
			1.322		
II	.324–.437	.375 ± .013		.375*	.372
			1.343		
III	.423–.592	.506 ± .024		.500	.496
			1.303		
IV	.564–.761	.646 ± .029		.661	.632
			1.242		
V	.705–.931	.821 ± .031		.875	.824
	Six-instar Families			*If Ratio=1.263*	*If Ratio=1. 239*
I	.268–.324	.287 ± .012		.287*	
			1.263		
II	.324–.423	.363 ± .015		.363*	.356
			1.229		
III	.409–.507	.445 ± .017		.459	.441
			1.274		
IV	.521–.649	.567 ± .023		.579	.544
			1.253		
V	.634–.832	.711 ± .026		.731	.625
			1.177		
VI	.747–.959	.837 ± .035		.922	.835

* Mean by actual measurement.

to that which Gaines & Campbell (1935) found for the black cutworm, some of which have six, and some seven instars. Of course it does not follow that all the larvae in any one family will have the same number of instars in their development, and in fact evidence was obtained from another source indicating that they may vary. Our curves can only show what the predominant number appears to be for each family.

By considering all the five-instar families together, and all the six-instar families likewise, the mean head width for each instar has been calculated. From these can be calculated a growth ratio for each ecdysis, a mean ratio for all the ecdyses, and a set of theoretical mean head widths to test the possible application of Dyar's law. Prebble and Bedard had found that this law could be applied to the species they studied. Our findings are indicated in table 1.

If one has only the first two instars from which to derive a ratio, the

theoretical means would be those given in the fifth column. If the mean of all the ratios is used, the figures in the sixth column are obtained. As would be expected, the latter fall nearer the actual means than the former. Bedard had found for *D. pseudotsugae* that the mean head width for 200 larvae in the first instar was .523 mm., and for 200 in the second, .615 mm. The ratio between these is 1.175, and if one attempts to determine the succeeding instars on the basis of this ratio one obtains seven, with the mean width of the last 1.37 mm. This falls between his observed actual mean of 1.38 and the theoretical 1.34. Yet he shows definitely that there are only five instars in this species, so that use of the ratio between the first two instars to determine the number of succeeding leads to error.

Of course a sure way of obtaining the growth ratio of any particular larva is to measure its head before and after an ecdysis. This is impracticable with this species, but if a large number of larvae are removed from the bark and placed in a dish, those few which are about to molt may do so in a day or two. When molting this way they are unable to shed completely their exuviae, so that both old and new head capsules become available for measurement. However, because the capsule is split in molting, the width of the frons alone (after it has hardened and acquired pigment) can be used. It is of interest to note in this connection that Bedard had used measurements of the frons as well as of the complete heads to determine instars. Since there is a more or less definite size relation between the two, a ratio obtained from the one should apply equally well to the other. Strangely enough we were unable to detect the least increase in size in five of the 37 individuals so measured. The highest ratio obtained was 1.25 in one instance. Only three others attained 1.2, and the average for the entire lot was 1.09. It is difficult to reconcile this figure, implying 12 or 13 instars, with the results obtained above. It is true that most of these frons measurements were made on older larvae, and that in both sets of families the ratio between the last and penultimate instars is decidedly lower than between earlier instars. In seeking an explanation for the extremely low figure of 1.09 it was thought that perhaps the frons is proportionately smaller in the later instars. But a series of measurements on all sizes of normal larvae gave a head width to width of frons ratio of about 1.58 in all instars. We next considered the possibility that the old frons flattened out during molting and thus appeared broader. This was tested by measuring a series of frontes from the exuviae found with pupae, and comparing them with those taken on individuals in the prepupal period. The means of both agreed closely. The third, and most unlikely, possibility is that the new capsule grows a little even after it has *apparently* hardened, *i.e.*, after it has acquired pigment and been measured by us. It is concluded then that this technic is faulty, because the larvae molted abnormally. The larvae are apparently susceptible to the partial desiccation when placed in dishes, and the new capsule is unable to attain its normal size.

To estimate the approximate duration of each larval stadium Prebble had taken the interval between the date when the particular instar formed the majority of the population, and the date when the succeeding

instar formed a similar proportion of the population. Bedard, using Taylor's method, counted the number of days from the first appearance of one instar to the first appearance of the next, and the number of days between the last dates of appearance of the same two instars, added these two numbers together and divided their sum by two. Our analyses of the series of head measurements according to dates of collection showed that practically all stages could be found in random samples at any time during the season. This suggests a probable long period of oviposition, an overlapping of generations, and a lack of homogeneity of growth rate even in the same family. (See below and fig. 7.) Hence it is evident that neither of these methods could be used successfully here.

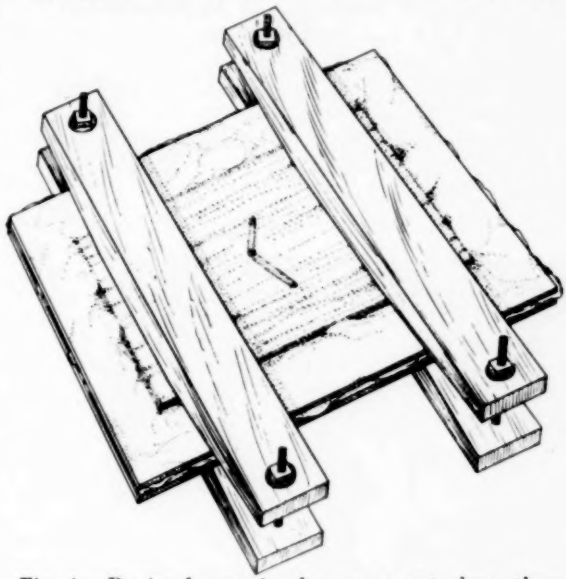

Fig. 4.—Device for rearing larvae so as to keep them under daily observation. Explanation in text.

In order to get more accurate information about larval activities we prepared a device which enabled us actually to watch the larvae from day to day. For the best results a piece of bark is selected which contains a large number of eggs in a gallery at least several inches removed from other galleries. The outer bark is removed from a rectangular area of about 3 by 5 inches, after which the external surface of the inner bark is smoothed off as much as possible. It is essential that this be done in order to have the piece of uniform thickness throughout. The bark is now removed from the tree or log and immediately placed between two plates of glass (old 5 by 7 inch photographic plates answer very well). The parent beetles, if present, should be removed first, and care must be taken that none of the eggs (or young larvae) are displaced. It requires considerable pressure to keep the plates close to the bark, and thus prevent warping with the subsequent falling of the active larvae out of their tunnels. The success of this rearing method depends in large measure upon keeping the inner surface of the bark in intimate contact with the glass. Elastic bands as used by Bedard were not satisfactory, so we resorted to the device illustrated in fig. 4. Four strips of wood, each about $7\frac{1}{2}$ inches long by $1\frac{1}{4}$ inches wide by one-half inch thick, were prepared to serve as two pairs of clamps. Bolts were placed about a half inch

from each end and the pieces of wood were beveled so that only the center 2 inches of each was in actual contact with the glass. In this way, on tightening the nuts, pressure was applied only directly over the bark. (Without beveling, the pressure over the borders of the glass caused a large amount of breakage.) It was found that the larvae got along best when the bark was kept quite damp, so cotton was packed around the bark and moistened daily. When not under actual observation the entire device was wrapped in black cloth or paper and kept at a constant temperature of about 23–24° C.

With this apparatus it was possible to watch, for various lengths of time, the progress of 31 families, including 374 larvae. The dates of hatching were obtained for 218 eggs, the dates of ecdysis accurately known in 552 instances and estimated in about another hundred. Of the 50 larvae that succeeded in pupating, the time of hatching was obtained for 28, so that the duration of their entire larval life is known. Moreover, the number of instars and duration of stadia are known from *direct observation*.

Fig. 5.—Live larvae and their frass trails, photographed by B. H. Walden through the glass of the observation rearing device, (×6). The larva second from the left had been underneath for some distance and the place where its frass trail again strikes the surface is plainly seen.

There is a very strong tendency for the larval tunnels to run with the grain, fig. 5; *i.e.*, perpendicular to a transverse egg gallery. Even when the latter is not transverse but inclined, the larval tunnels which start off at right angles to this almost immediately diverge from their original direction to become longitudinal. However, there are instances where the larval tunnels, especially those nearest the ends of the egg gallery, bend in a curve toward the latter. There are many instances where the egg gallery is V shaped. In case the female completes one arm before laying any eggs in the other arm of the gallery, the larvae hatching later almost always eventually encounter the frass trails of older members of the family. If, as Trägårdh (1930) believes, the larva is able to detect the degree of decomposition or dryness of the surrounding bark and thus be guided in the proper direction, there is the apparently aber-

rant behavior of occasional larvae suddenly changing direction and crossing the frass trails of neighboring larvae, or even proceeding back toward the egg gallery in their own or another's frass trail! Yet a larva never failed to change its direction whenever approaching the cut edge of the piece of bark.

By measuring the length of its tunnel each day a curve can be plotted for each larva, such as is shown for three individuals in fig. 6. It was found

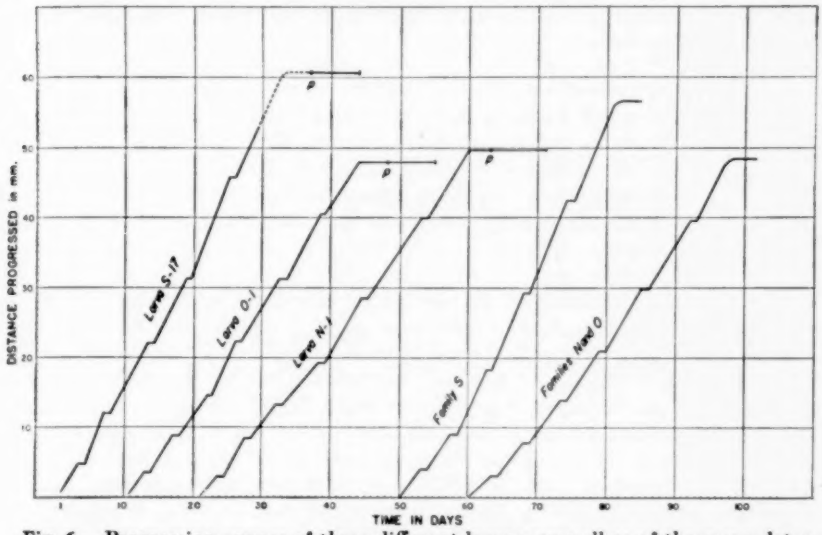

Fig. 6.—Progression curves of three different larvae, as well as of the mean determined for three families. The "p" indicates the place at which pupation occurred.

that accompanying each ecdysis there is a period of almost a day during which the larva does not feed. This is represented by a short horizontal line along the curve. Also obtainable from these curves are the total duration of larval life, the duration of each stadium, and the number of stadia. For example, larva N-1 had seven stadia, the duration of which and the distance progressed during each being as follows:

Instar I,	4 days,	2.5 mm.
II,	5 days,	5.3 mm.
III,	4 days,	5 mm.
IV,	6 days,	6.1 mm.
V,	7 days,	9.3 mm.
VI,	7 days,	11.4 mm.
VII,	11 days,	10 mm.

It did not tunnel for about three and a half days before pupation, and remained eight days in the pupal stage. In like manner larva S-17 went through six instars in 36 days, tunneling a distance of 60.8 mm. Between the 29th and 33rd day it was not visible (indicated by the dotted

line in the curve), having gone underneath the surface of the bark. It was later dug out on the day of pupation at a point 8 mm. beyond where it had disappeared.

The larvae of families N and O taken together present a curve showing a much slower rate of tunneling than those of family S. These curves also show what has been found true in general for the other families as well, namely that there is a positive correlation between the number of instars and the duration of the larval period. Larvae have completed their development in six to 12 instars with the mean duration of the larval period as follows:

For six instars, 35 days (mean of seven larvae)
For seven instars, 42 days (mean of seven larvae)
For eight instars, 49 days (mean of two larvae)
For nine instars, 64 days (only one larva)
For ten instars, 71 days (mean of three larvae)
For eleven instars, 89 days (only one larva)
For twelve (?) instars, 85 days (only one larva)

The instances of nine to 12 instars all occurred in family A, which developed under abnormal conditions. It was one of the first families reared, and the bark was not kept tightly against the glass at all times. This resulted in drying of the bark alternating with flooding when an attempt was made to remedy the situation. This shows, however, that the larvae are potentially capable of molting more than the normal number of times. Some of the irregularities in our curves, figs. 1 and 2, discussed in the first part of this paper, may be due to retarded larvae which are going through a greater number of instars. In this connection it is of interest to note that Metcalfe (1932) was unable to arrive at any satisfactory conclusion concerning the number of instars in the anobiid, *Sitodrepa panicea* L. The curve of head-capsule measurements plotted from random collections presented nine peaks which the author hesitated to accept as representing a like number of instars, "a number hitherto unprecedented in the Coleoptera." Instead, evidence was presented to indicate that four of the peaks belonged to one sex and five to the other.

There seems to be no correlation between the distance tunneled and the duration of larval life. However, the mean of the distance traveled increased in successive instars, as was to be expected.

Different larvae showed great variation in their rate of tunneling, as shown in fig. 7. Here the slope was obtained from curves similar to fig. 6 simply by connecting the point representing the time of hatching with the point where the larva stopped tunneling in preparation for pupation. For larvae A-4 and A-10 these curves extend to the time of pupation. Larva N-2 went underneath the bark surface during the seventh stadium so that the dotted line was continued from this point to the day when the average for this family pupated. Larva Q-d was lost to view during the sixth stadium, the dotted line indicating the *probable* course to pupation (the average duration of larval life not being known for family Q). It can be readily seen that larva A-10 had traveled about 13 mm. in the

first 20 days, whereas larva N-2 had gone just about twice that far, and larva Q-d about three times.

After molting, and when the new head capsule has hardened, the larva turns around in its gallery and eats the exuviae. Blackman suggested that the larvae of *P. hopkinsi* have the same habit because he did not always find their exuviae in the frass trials. Prebble had likewise encountered similar difficulty with the three species previously referred to. However, we have found that only the relatively soft body cuticula

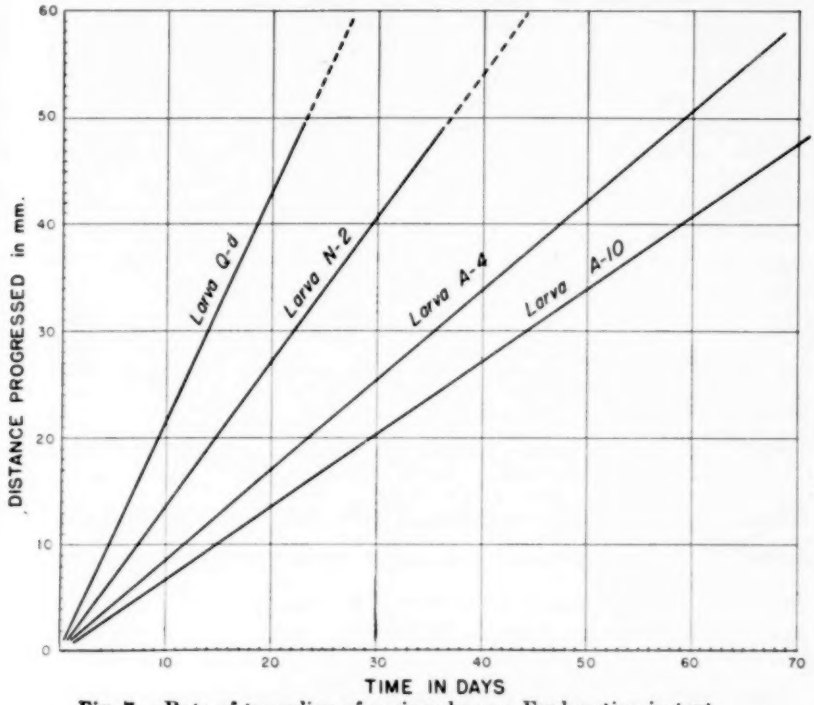

Fig. 7.—Rate of tunneling of various larvae. Explanation in text.

is eaten, leaving the head capsule. This gets broken up so that only certain parts, especially the mandibles, may be later distinguished. At intervals the larva turns around and packs the newly voided frass with its head, using its mandibles to tamp it down firmly. During this process the remains of the capsule often become buried or obscured. With material brought in from the field we have found it possible, by careful manipulation under a binocular, to expose fragments at intervals in the tunnels. The finding by this method of five groups of capsule fragments in a few tunnels had indicated to us that there could be at least six instars.

Before pupation the larva in the last instar spends about a day and a half during which it does not progress farther, but simply enlarges the end of its tunnel to form a pupal cell. This may be called the antepre-

pupal period, and is followed by a prepupal period during which the larva is quiescent for almost two days. It shortens slightly, loses some of its curvature, becomes creamy white, and thickens around the thorax where the imaginal buds of the pupal structures are forming underneath.

Summary.—It is not possible to determine the number of instars by measuring the head capsules of mixed lots of larvae taken at random from various localities in the field. If the measurements are considered separately by families the evidence indicates that some larvae go through six instars and some through five.

A special device is described which allowed the daily observation of larvae reared from hatching to pupation. In this way the exact number of instars and duration of stadia were obtained for each larva. Six, seven and perhaps eight instars appear to be the usual number under these conditions, though in one family nine to 12 occurred. There is a positive correlation between the number of instars and the duration of the entire larval period. The rate of tunneling was found to be quite variable with different larvae. Accompanying each ecdysis there is a period of almost a day during which the larva does not feed, and preceding pupation a period of about three and one-half days during which the tunnel is not lengthened.—11-25-36.

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Effect of Moisture on Emergence of the Ragweed Borer *Epiblema strenuana* Walker, and Its Parasites

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Entomological literature contains records of numerous observations dealing with the effect of moisture on insect development. The majority of these references concern the influence of atmospheric moisture. Those which include data on the direct effect of liquid water, to which the name "contact moisture" has been applied, are indeed scarce.

Workers who have made interesting contributions to the study of this

phase of insect ecology include Townsend, Babcock and Breitenbecher. These experimentors have shown that with certain insects the lack of contact moisture may retard development, may arrest development, may prevent return to an active state after hibernation, and may cause a change in life habits.

Lack of contact moisture retards the development of both the codling moth and European corn borer. Townsend (1926) found that soaking

Table 1.—Emergence of ragweed borer adults and parasites from larvae subjected to various moisture conditions.

Test No.	Treatment of Larvae*	No. Larvae	Emergence of Adults: Borers		Emergence of Adults: Parasites		Total Emergence	
			no.	*per cent*	*no.*	*per cent*	*no.*	*per cent*
1	Check; no contact moisture applied	40	0	.0	0	.0		.0
2	Soaked every seventh day starting April 29	41	39	95.1	2	4.9	41	100.
3	Soaked every seventh day starting May 20	41	31	75.6	7	17.1	38	92.7
4	Soaked every seventh day starting June 10	39	31	79.5	5	12.8	36	92.3
5	Soaked every seventh day starting July 1	39	6	15.4	2	5.1	8	20.5
6	Soaked once only on April 29	41	1	2.4	0	.0	1	2.4
7	Soaked once only on May 20	42	7	16.7	4	9.5	11	26.2
8	Soaked once only on June 10	40	18	45.	2	5.	20	50.
9	Soaked once only on July 1	39	6	15.3	1	2.6	7	17.9
10	Soaked once only on July 22	27	0	.0	0	.0	0	.0
11	Soaked every seventh day, April 29 to May 6	40	15	37.5	2	5.	17	42.5
12	Soaked every seventh day, April 29 to May 13	40	16	40.	3	7.5	19	47.5
13	Soaked every seventh day, April 29 to May 20	40	16	40.	1	2.5	17	42.5
14	Soaked every seventh day, April 29 to May 27	39	20	51.3	3	7.7	23	59.
15	Soaked every seventh day, April 29 to June 10	38	32	84.2	4	10.5	36	94.7
16	Soaked every seventh day, April 29 to June 24	41	32	78.	5	12.2	37	90.2
17	Placed in water-saturated atmosphere for periods of 24 hours every seventh day starting April 29	41	0	.0	1	2.4	1	2.4
18	Kept out of doors in screen cages	39	28	71.8	6	15.4	34	87.2
19	Placed out of doors in screen cages during rainy periods only†	39	29	74.3	1	2.6	30	76.9

* Soaking treatment consisted of immersion in water for one minute. Moisture treatments were terminated on July 29. All material was kept in shoe boxes in an outdoor insectary except as otherwise indicated.

† Whenever rain occurred while larvae were still inside the insectary they were artificially soaked with water for one minute as soon as possible thereafter.

the cocoons of hibernating codling moth larvae shortened the length of time to pupation and also the period between pupation and adult emergence. The fact that European corn borer larvae react in a similar way has been demonstrated by Babcock (1924).

Their work with these insects has also shown that the lack of contact moisture may arrest development. In Townsend's experiments (1926) the percentage of hibernating codling moth larvae which attained the pupal stage was greater when the larvae were soaked in water than when they were not subjected to such treatment. Babcock (1924) proved that exposure to contact moisture is absolutely essential for successful

pupation of hibernating corn borer larvae. High atmospheric humidity did not induce transformation. When hibernating larvae were deprived of contact with water during any month from November to April an increased mortality resulted.

The effect of water in breaking up hibernation is also pronounced. Breitenbecher (1918) found that Colorado potato beetles, which were hibernating in dry soil, emerged when the latter was moistened with water, provided the temperature was above 14° C. In the case of this insect, however, exposure to moist air until an appreciable quantity of water was absorbed produced the same result. Beetles remaining in dry soil, on the contrary, died without coming out of hibernation. Contact moisture is also involved in breaking up hibernation of both the codling

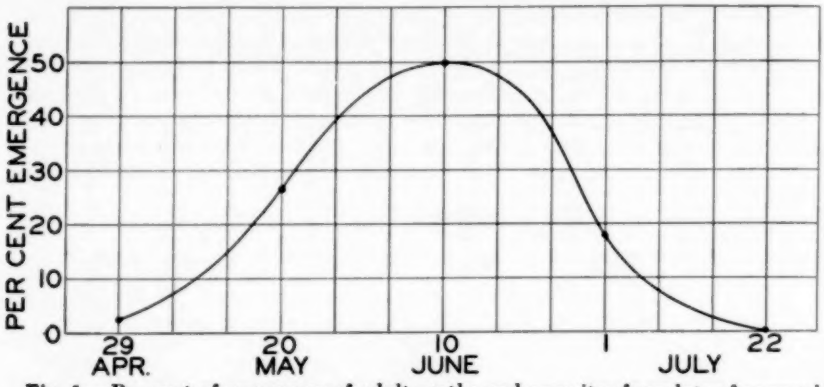

Fig. 1.—Per cent of emergence of adult moths and parasites from lots of ragweed borers soaked once only on the dates indicated.

moth and the European corn borer, as shown by Townsend (1926) and Babcock (1924).

Another publication of Babcock (1927) presents evidence to show that abundant contact moisture in the dormant period is an important factor in producing a two-generation life cycle. The single-brooded life cycle predominates in sections where the winter season is drier than in those regions where two broods are produced annually. This investigator showed experimentally that a change in contact moisture conditions during the dormant season altered the percentage of individuals passing through one or two broods.

While studying parasitism of the ragweed borer, *Epiblema strenuana* Walk., Rice (1935) observed that free water was apparently essential to the normal development of both spring-brood larvae and their parasites. Preliminary experiments showed that the number of adult moths and parasites produced was considerably lower when contact moisture was not supplied. Exposure to high humidity did not materially increase the number which emerged. Weeds, infested with borers and from which only small numbers of adult moths and parasites had emerged during the period when they normally appear, yielded large numbers of each after

being soaked in water late in the season. Consequently, the statement was then made that parasitism data based on emergence from ragweed borer material kept in dry cages may result in erroneous conclusions.

The present study was conducted to determine more specifically the influence of moisture on the ragweed borer and its parasites. An experiment was outlined to ascertain the effect of time and number of wettings on the period and percentage of adult emergence.

Methods.—Dead ragweed stalks infested with mature borer larvae were collected in the field between April 4 and 18. The weeds were split open to locate the insects and small sections of weed, each containing one or more larvae, were cut out. These were placed in glass jars for several days, until the insects had repaired their cocoons. Subsequently, those which appeared normal were divided into lots of approximately 20, which were placed in separate cylindrical screen cages for convenience in handling during moisture applications. The tests were run in duplicate, two lots of approximately 20 larvae being used for each of the treatments listed in table 1. All of the screen cages, with the exception of the two used in test No. 18, were kept in shoe boxes in an outdoor insectary. Readings made with a dewpoint bulb showed that the atmospheric humidity within the shoe boxes was practically the same as that of the surrounding air; the greatest variation being only 7 per cent. The humidity in the insectary ranged from 35 to 90 per cent during the period in which the experiment was in progress. The only source of light in the boxes was a single hole cut in the side of each and fitted with a glass tube. The insects which emerged were attracted to the light and entered the tubes where they were trapped by a celluloid funnel fitted in the mouth of each tube. They were removed and recorded once each week. All pieces of weed were cut open early in October and the stage of development of those insects which had failed to reach the adult stage was noted.

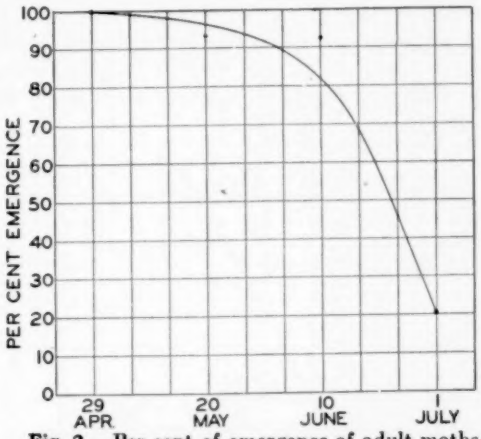

Fig. 2.—Per cent of emergence of adult moths and parasites from lots of ragweed borers soaked every seventh day starting on the dates indicated and continuing until July 29.

The following three species of parasites which emerge early in the spring were excluded from consideration in this experiment: *Glypta rufiscutellaris* Cress., *Calliephliates notanda* (Cress.) and *Bassus erythrogaster* Vier. All attain maturity sufficiently early that the moisture treatments applied in this series of tests would have little or no effect on their development. *G. rufiscutellaris* is the most abundant parasite of the spring

brood of the ragweed borer in Delaware. When the effect of moisture on emergence of parasites is spoken of, reference is made collectively to species which appear later in the season, most important of which are *Macrocentrus delicatus* Cress., *Pristomerus ocellatus* Cush., *Cremastus minor* Cush., *Cremastus epagoges* Cush., and *Bassus simillimus* Cress.

Results and discussion.—Table 1 includes the records of the emergence of moths and parasites from the duplicate lots of ragweed borers subjected to 19 different moisture treatments.[1] Inspection of this table will show that the various treatments had a marked effect on development since the percentage of the insects reaching the adult stage varied

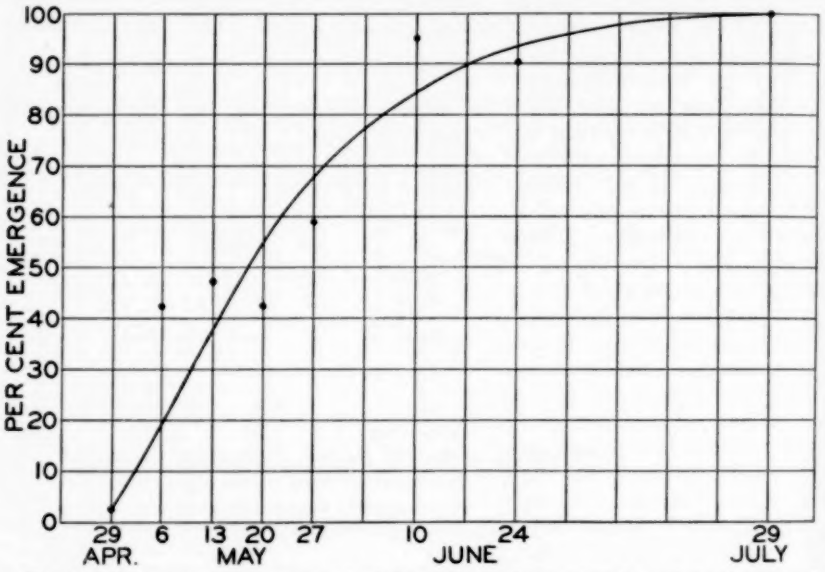

Fig. 3.—Per cent of emergence of adult moths and parasites from lots of ragweed borers soaked every seventh day starting April 29 and continuing until the dates indicated.

from 0 when no contact moisture was applied or when it was applied very late in the season, to 100 when the insects were soaked at weekly intervals. These differences were more marked than had been expected, since observations in 1935 indicated that a small percentage of ragweed borers and a somewhat larger percentage of their parasites are able to develop under dry conditions. It is probable that similar results would have been obtained during the current season if larger lots of larvae had been used.

Effect of Time of Wetting on Emergence.—The time of wetting strongly affected the percentage of emergence. This influence is clearly shown in figs. 1, 2, and 3.[2] It is apparent from fig. 1 that a single one-

[1] The results obtained from the duplicate lots of borers have been combined in the table. The maximum variation in emergence between duplicate lots was 15 per cent.

[2] Each horizontal space on all figures represents an interval of one week.

minute soaking was sufficient to bring about an emergence of 50 per cent if applied at the most critical time. This was during the first part of June the period when pupation of the borer larvae normallp takes place. Single soakings applied before or after this time induced the development of a smaller percentage of the insects. Figure 2 shows that the percentage of borers and parasites which emerged as adults became increasingly less as the weekly applications of contact water were started later in the season. When treatments did not commence until July 1 a great reduction in adult emergence resulted. The effect of discontinuing the weekly soakings at dates progressively later in the season is demonstrated in fig. 3. When they were terminated before June 1 an emergence resulted which was considerably below that produced when the contact moisture treatments were kept up until near the middle of June.

Variation in the time of wetting affected also the period of emergence. Figure 4 is designed to illustrate this fact. The unbroken line, which is the curve of emergence from a lot of material wet at weekly intervals starting early in the spring, may be considered as approximately the normal emergence from borers placed under ideal moisture conditions. It is evident by comparing this curve with the others in the diagram that the adults came later in the season when the application of moisture was delayed.

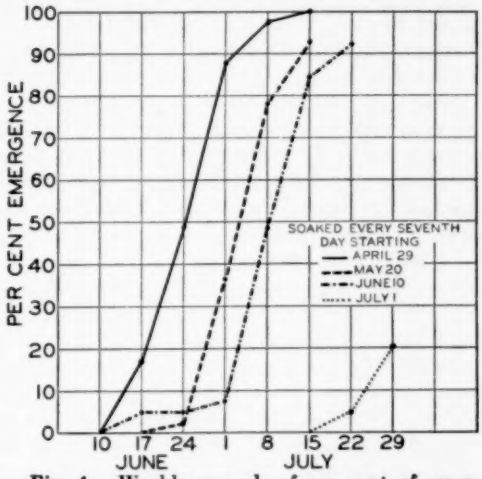

Fig. 4.—Weekly records of per cent of emergence of adult moths and parasites from lots of ragweed borers receiving soaking treatment as indicated.

EFFECT OF NUMBER OF WETTINGS ON EMERGENCE.—The number of wettings influenced the transformation of the ragweed borer and its parasites. Information on this fact may be gleaned from figs. 1, 2, and 3 and table 1. Figure 1 shows that a single soaking for one minute is not enough to bring out the maximum number of adults. Data on the minimum number of one-minute soakings required to produce normal development are not available but it is clear that several are necessary.

EFFECT OF HIGH HUMIDITY ON EMERGENCE.—The data recorded for test No. 17, table 1, show that periodic exposures to a saturated atmosphere did not induce normal development. No moths and but one parasite was produced in this instance. The dry check (test No. 1) was exposed to conditions of high humidity during rainy periods and yet it yielded no adult insects. As previously mentioned, a relative humidity of 90 per cent was sometimes attained in the insectary.

COMPARISON OF ARTIFICIAL WETTING WITH WETTING BY RAIN.—A higher percentage of insects emerged as adults when artificial soaking was applied at weekly intervals all season than when the larvae were exposed to rains. An emergence of 100 per cent resulted in test No. 2, in which the material was soaked at intervals of one week, while the corresponding figures for tests 18 and 19, with exposure to rain, were 87.2 and 76.9 per cent, respectively (see table 1). This may be accounted for by the scarcity of rain during May and the first 10 days of June.

STAGES IN WHICH DEVELOPMENT WAS ARRESTED.—When the pieces of ragweed used in this experiment were opened in the fall it was found that 385 insects had died without reaching maturity. Of this number 95.4 per cent died as mature larvae, 3.6 per cent as pupae and 1 per cent as parasite pupae. No method was devised to determine how many of the dead borer larvae contained dead parasite larvae. Since so large a proportion of borers died without pupating it is apparent that lack of contact moisture prevents normal pupation of the ragweed borer.

LENGTH OF SOAKING TREATMENT.—The one-minute soaking treatment probably did not produce the maximum effect on development. This length of exposure was selected arbitrarily and it is probable that further experiments will show longer periods of immersion to be productive of more striking results. Observations during the last two years indicate that such is the case but no conclusive proof is as yet available.

EFFECT OF MOISTURE ON THE PARASITES.—No definite conclusions regarding the effect of moisture on development of the parasites can be reached from the results of the investigations discussed herein. The percentage of parasitism was so variable (ranging from 0 to 35 per cent in lots of 20 larvae) that the recorded differences in the number of parasites produced are considered insignificant. However, a definite relationship between contact moisture and parasite emergence has been shown previously by the work conducted by Rice in 1935. In those experiments a five-minute immersion of a lot of borers on July 17 followed by a similar treatment on July 25 produced a heavy emergence of parasites as well as ragweed borer moths. A total of 48 parasites (25 *Macrocentrus delicatus*, 8 *Cremastus minor*, and 15 *Bassus simillimus*) emerged from this lot of ragweed borers subsequent to July 19, while an average of but six parasites, including representatives of the three species named above, were produced from three similar lots of ragweed which had been kept dry.[3] The presence of such a small number of dead parasite pupae in the fall, when the weeds used in the experiment were cut open, might possibly indicate that parasite development also stops at the larval stage if adequate moisture is not available. Since all of the species of parasites under consideration feed internally it would seem that the physiological condition of the host, which is affected by moisture, must in turn exert an influence on the parasite.

Summary and conclusions.—Published information shows that contact moisture exerts an influence on certain insects which is not produced by atmospheric moisture. Data are available which demonstrate that a lack of contact moisture may retard insect development, may arrest

[3] Unpublished data.

development, may prevent the return to an active state after hibernation and may cause a change in life habits.

An experiment was conducted during 1936 to determine more specifically the effect of moisture on the emergence of spring-brood ragweed borers and their parasites. Two lots of approximately 20 larvae each were exposed to each of 19 different moisture treatments including subjection to dry conditions in an insectary, normal rainfall, saturated atmosphere, and one-minute immersions in water. The soakings were administered a varying number of times at weekly intervals. Records of adult emergence were kept each week and the stage reached by those insects which failed to attain maturity was noted in the fall.

An adult emergence of 100 per cent resulted from the lots of insects which were soaked for one minute at weekly intervals throughout the season while no adults were produced in those lots which received no contact moisture or were not wet until very late in the season.

The time and the number of wettings proved to be important factors in emergence. A marked reduction in the percentage of adults produced resulted when soaking of the insects was discontinued before the first of June or when this treatment was not started until July 1. The percentage of adults which emerged after a single soaking treatment applied during the first part of June (the time when ragweed borer pupation normally takes place) was twice as great as the percentages resulting from single treatments applied three weeks earlier or three weeks later. Transformation to the adult stage was delayed when contact moisture applications were started late. The minimum number of one-minute wettings necessary to produce a high percentage of adult emergence was not determined. It is apparent, however, that several would be required. The maximum effect produced from one soaking was a 50 per cent transformation to the adult stage.

High humidity alone did not induce normal emergence. Only one insect out of the 41 periodically exposed to saturated humidity attained the adult stage.

For the most part, lack of contact moisture arrests the development of the ragweed borer in the larval stage. More than 95 per cent of the borers which failed to attain maturity died as full-grown larvae.

Apparently, contact moisture influences development of the larval parasites of the ragweed borer. Definite conclusions in this particular cannot be drawn from the data presented.—11-30-36.

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Observations on Poison Baits for Corn Ear Worm Control

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Use of bait pails, poison baits and poison-spray baits for corn ear worm control in the United States dates back to the earliest investigations of this insect. Many entomologists have used some bait method for the control of the ear worm or boll worm. Some of the results are briefly mentioned in literature but probably a larger proportion were never published because they were unfavorable. At the Maryland station work on baits for the control of the ear worm has been in progress for 10 years. The object of these experiments has been to investigate in the laboratory and in the field the possibility of finding an efficient bait for ear worm control and an effective method for its use. These investigations have involved determinations of the relative attractiveness of various bait ingredients, determination of the relative efficiency of common soluble insecticides for making poison baits, and observations on various methods of using baits in the field. Briefly, the results to date indicate: (1) Sucrose is the most attractive of the more common sugars, and further, a concentrated bait of sucrose is superior to a fermenting bait. (2) Sodium arsenite appears to be the fastest acting of the soluble insecticides employed. (3) Moths seem hesitant to take such organic poisons as pyrethrum and nicotine. (4) Some baits in various types of containers have at times given encouraging results, but were never efficient enough for recommendation as control measures.

During the summer of 1936 experiments were confined to the use of a cane sugar–sodium arsenite bait. This was composed of cane sugar 15 pounds, sodium arsenite 1½ pounds, and water 2 gallons. Observations were made late in the summer after moths had become numerous in the field. The object of these experiments was to determine the relative efficiency of various methods of applying the bait in the field as indicated by the kill of moths and by the reduction in oviposition on the silks, rather than by the infestation of the ears. This was done so that the treatment could be changed on the same plot of corn and results of the treatments directly compared.

Three fields of late sweet corn were available for these experiments. In the first field, which was composed of several varieties, two plots were used. On the first plot, about one-quarter acre, oviposition counts were made for several days preceding treatment; following this poison bait traps were placed about the four sides of the field at intervals of 20 feet, and oviposition counts again made. These bait traps were metal containers 4 by 6 by 12 inches, over the top of which a screen trough was fitted in such a manner that moths could feed on the bait and escape without drowning. Finally the poison bait was placed on plants of the two outside rows, that is to say a row on each side, followed by more oviposition counts. The poison bait in this case was applied daily with a compressed-air sprayer from September 5 to September 9. During the

time poison baits were used, dead moths were picked up at more or less regular intervals. The results of these experiments are given in table 1.

It will be noticed that the ears free of eggs increased from 6.6 to 80 per cent after this treatment.

On September 9, an oviposition count was made on the silks of an additional lot of 100 new ears. There were 36 eggs on 21 ears, or an average of .3 egg per ear. Seventy-nine ears were free of eggs.

Apparently moths feeding on this arsenic bait in the field die in a short time and usually do not travel far from the place of feeding. Nearly all

Table 1.—Experiments with poison baits to control corn ear worm, plot 1, College Park, Md.

Date	Total Eggs	Av. Eggs per Ear	Per Cent Ears Free of Eggs	Dead Moths Recovered
	Oviposition Preceding Bait Traps*			
Aug. 26	136	4.5	6.6	
Aug. 27	155	5.1	6.6	
Aug. 31	135	4.5	6.6	
	Poison Bait Traps in Operation			
Sept. 2	78	2.6	36.6	
Sept. 3	63	2.1	13.3	13
Sept. 4	58	1.9	13.3	
Sept. 5	61	2.	40.	19
	Poison Traps plus Poison Bait Sprayed on Plants†			
Sept. 6				42
Sept. 7	20	.6	66.6	32
Sept. 8	13	.4	83.3	53
Sept. 9	8	.26	80.	53
Sept. 11				189
Sept. 13				140
Sept. 15				132

* All oviposition counts from 30 ears. † Spray first applied September 5.

moths recovered were picked up within 4 or 5 feet of the poisoned plants. Many poisoned moths sought protection under grass or corn leaves before dying. Many of the poisoned moths were eaten by ground beetles, mice or other animals, as was indicated by insect fragments on the ground. Whole moths only and not fragments were recorded. Analyses of two lots of dead moths were made for arsenic by the Gutzeit method. One lot contained .0051 mg., the other .0056 mg. per moth. These results compared favorably with results obtained in laboratory toxicity tests.

In plot 2, field 1, about one-eighth of an acre, one application of bait was made to a row on each side with a compressed-air sprayer. The object of this experiment was to determine the residual effect of the poison. Dead moths were picked up daily for a period of one week. Ninety-eight dead moths were recovered; an average of 14 per day. The daily variation in the number of dead moths recovered ranged from 12 on the second day to 19 on the fifth day after application of the bait.

In a second field, of 3 acres, 60 plants were sprayed with bait on Sep-

tember 5. These plants were on a side of the field adjacent to another sweet-corn field. Dead moths were picked up every day until September 13. A total of 249 moths was recovered; an average of 35 per day. The fewest (27) were collected on the eighth day after application and the most (50) on the third day. Oviposition counts were made on the eighth day after application. On the side of the field adjoining the treated plants 162 eggs were recorded on 71 of the 100 ears examined, or an average of 1.6 eggs per ear. On the far side away from the treated plants, as well as from the adjacent sweet-corn field, 59 eggs were found on 33 of the 100 ears examined, or an average of .6 egg per ear.

In the third field, about 1 acre, the method of application was to dip the silks into a tin can containing the poison bait. One application on September 13 was made to a single row of corn around the entire field and to one row through the middle. In this experiment, results were based on oviposition counts rather than on dead moths recovered, although 27 moths were picked up on the second day and 117 on the fourth. Oviposition counts on September 12 showed 255 eggs on 84 of 100 ears examined, or 2.5 eggs per ear. On September 16, counts revealed 95 eggs on 51 of 100 ears, an average of slightly less than one per ear. This amounted to a 62 per cent reduction in three days.

The amount of bait necessary to treat an acre of corn varies with the method used, and the number of plants treated. One quart should be sufficient to treat an acre when it is applied to the silks from a tin can. The spraying method requires more bait. Rain may necessitate repetition of treatment. No rain fell during the period of these experiments, hence this effect on the residual poison was not noted.

During the tests it was observed that large numbers of moths other than the ear worm were killed. These included the fall army worm, *Laphygma frugiperda* S. & A., a pest of serious import on late sweet corn in Maryland. Other Lepidoptera determined[1] were *Feltia ducens* Wlk., *Agrotis ypsilon* Rott., *Scotogramma trifolii* Rott., *Cirphis unipuncta* Haw., *Cirphis phragmatidicola* Gn., *Polia renigera* Steph., *Prodenia ornithogalli* Gn., *Prodenia eudiopta* Gn., *Delta ramosula* Gn., all of which are more or less injurious to crops. The actual percentages of the various species killed were not determined, but *F. ducens*, *P. renigera* and *P. ornithogalli* were found in comparatively large numbers.

Whether poison baits will prove an efficient means of controlling the corn ear worm is yet to be seen. The cheapness and simplicity of the tin-can method of application, should this method prove efficient, will make it practical even for the grower of sweet corn for canning.—12-21-36.

[1] Through the courtesy of J. F. G. Clark, U. S. National Museum.

THE PENNSYLVANIA quarantine relating to gypsy moth infestation within the state was extended on November 20, 1936, to include area not previously known to be infested, and to regulate the movement of products within the quarantined area so as to prevent reinfestation in eradication areas.

COTTON STATES BRANCH

PAPER-READING SESSION, ELEVENTH ANNUAL MEETING

Jackson, Miss., February 1936

Cotton Flea Hopper Control Tests

Using the Latin Square Plat Arrangement and Analysis of Variance[1]

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Several articles have appeared recently regarding the technic of field experimentation in entomology. Huber & Sleesman (1934) pointed out the requirements which govern a well-planned experiment. The experiment should be planned in such a manner that it shall yield a comparison of the different treatments as well as provide a means of testing the significance of such differences as are observed. Fisher (1932), Snedecor (1934) and Paterson (1933), as well as many others, have applied statistics to data obtained from various methods of plat arrangement that are applicable to entomology. This paper deals with the Latin square method of plat arrangement for comparing materials used in control studies of cotton flea hopper, *Psallus seriatus* Reut. The purpose of the investigations described herein was two fold, first to find out if this plat or block arrangement, using small blocks, could be used in cotton-dusting control experiments, second to find out which material gave the best control of cotton flea hopper nymphs.

The Latin square method of plat arrangement, a modification of the randomized block layout, applies where the number of replications is made equal to the number of treatments. The blocks within the square are arranged in a row-column system, so that each treatment occurs once in each row and once in each column, otherwise the arrangement is random. This layout is considered a very accurate method of experimentation, since it eliminates location differences, and allows an efficient method of statistical analysis. This analysis of variance is a process whereby the entire variation between the number of nymphs found on all the blocks might be split up into the variance due to rows, columns, treatments, replication of squares, interaction between replications and treatments, and that which is left over or an expression of the error.

In these experiments, four types of sulfur and a sulfur–syncrolite mixture were used to control cotton flea hopper nymphs on cotton. Two Latin squares of 36 blocks each were located in two fields of uniform cotton. Six blocks in each square were left as checks or untreated areas. Each block was nine rows wide and 68 feet long, making it one-twentieth of an acre in size. A buffer of about seven feet was left between the sides and ends of each block. All blocks except the checks were dusted in the early morning with a hand gun at the rate of 1 pound to each block. Applica-

[1] Technical contribution 339, Texas Agricultural Experiment Station.

[2] The writer is indebted to N. M. Randolph for assistance in obtaining the field notes.

tions were made on square No. 1 June 11, 18 and 25, and July 2. Infestations were made by recording the number of nymphs on 50 terminal buds at two points in each block. These records were made on square No. 1 on the following dates: June 10, 14, 17, 21, 24 and 28, and July 1

Table 1.—Arrangement of blocks in square No. 1, the initial infestation, the average infestation during the dusting period, and the average per cent kill in cotton flea hopper control experiments at College Station, Tex., 1935.

						Total of Rows§
E	B	C	F	A	D	
20*	18	27	24	20	28	
2.14†	3.28	1.86	4.28	24.14	5.71	41.41
84.87‡	74.23	90.25	74.78	Check	71.16	
B	E	F	C	D	A	
39	31	37	26	38	33	
4.28	2	5.57	4	2.57	21.57	39.99
84.48	90.88	78.71	78.25	90.44	Check	
C	A	E	D	F	B	
36	43	25	23	28	29	
4.28	18.29	2.57	2.43	3	2.43	33
88.14	Check	85.46	85.06	84.85	88.15	
A	C	D	E	B	F	
23	25	37	24	25	37	
20.71	5	2.43	2.43	2.57	5.57	38.71
Check	71.71	90.71	85.69	85.46	78.71	
D	F	A	B	C	E	
39	20	25	26	30	33	
2.57	5.71	21.14	3.28	2.71	2.71	38.12
90.68	59.62	Check	82.17	87.23	88.39	
F	D	B	A	E	C	
18	25	34	33	23	25	
4.86	3	3.57	19.29	4.14	5.28	40.14
61.81	83.03	85.15	Check	74.54	70.13	
			Totals of Columns§			
38.84	37.28	37.14	35.71	39.13	43.27	231.37

* The figure listed first in each block represents the initial infestation or the number nymphs per 100 terminals.

† The figure listed second in each block represents the average infestation or the average number nymphs per 100 terminals from June 14 to July 6, inclusive.

‡ The figure listed third in each block represents the average per cent kill.

§ The totals represents the total of rows and columns of the average infestation or the average number o nymphs per 100 terminals.

and 6. The average per cent kill was calculated by using the following formula: $\frac{X-Y\,(100)}{X}$ = actual per cent kill, Where X = the average per cent of living nymphs found on the check blocks during the period in which dust was being applied to the treated blocks, and Y = the average per cent of living nymphs found on each treated block during the dusting period.

The application of materials, infestation records, and the calculations of the per cent kill on square No. 2 were made in the same manner as for square No. 1. The applications of dust were made on the mornings of June 20 and 27, and the infestation records were made June 19, 24, 26, and 29, and July 3. The blocks in both squares were treated with the following materials: A, Checks or untreated blocks; B, 200-mesh sulfur containing 2 per cent magnesium carbonate;[3] C, 300-mesh sulfur con-

[3] Patented mixtures.

Table 2.—Arrangement of blocks in square No. 2, the initial infestation, the average infestation during the dusting period, and the average per cent kill in cotton flea hopper control experiments at College Station, Tex., 1935.

						Totals of Rows§
C	A	F	D	B	E	
21*	22	23	32	17	28	
3.50†	17.25	7.50	3.	2.50	2.75	36.50
72.51‡	Check	46.22	84.55	75.76	83.81	
E	C	D	B	F	A	
20	23	22	22	31	26	
2.25	2.	1.50	1.75	3.50	10.75	21.75
81.45	85.67	88.75	86.89	81.38	Check	
B	E	C	F	A	D	
29	20	18	16	22	35	
2	.50	2	3.75	13	3.75	25
88.62	95.88	81.68	61.34	Check	82.34	
F	B	E	A	D	C	
17	20	19	26	35	28	
3.50	2.75	1.25	18	3.25	2	30.75
66.04	77.32	89.15	Check	84.70	88.22	
D	F	A	C	E	B	
19	15	29	29	16	23	
.50	2.50	13.75	1.75	1.25	1	20.75
95.66	72.51	Check	90.06	87.12	92.3	
A	D	B	E	C	F	
16	13	25	13	13	17	
12.75	.75	2.25	2	1.50	2.25	21.50
Check	90.48	85.16	74.64	80.97	78.18	
		Totals of Columns§				
24.50	25.75	28.25	30.25	25.	22.50	156.25

* The figure listed first in each block represents the initial infestation or the number nymphs per 100 terminals.

† The figure listed second in each block represents the average infestation or the average number nymphs per 100 terminals from June 24 to July 3, inclusive.

‡ The figure listed third in each block represents the average per cent kill.

§ The totals represents the total of rows and columns of the average infestation or the average number of nymphs per 100 terminals.

taining 2 per cent magnesium carbonate;[3] D, 300-mesh sulfur unconditioned; E, 300-mesh sulfur containing 2 per cent lime; F, 300-mesh sulfur containing 2 per cent magnesium carbonate–syncrolite in a 70:30 mixture.

A comparison is made of the average per cent kill obtained from the various treatments in table 3.

It will be noted that the average per cent kill obtained from treatments, D, E, B and C differed but little, while that obtained from treat-

Table 3.—Average per cent kill obtained from treatments to control cotton flea hopper at College Station, Tex., 1935.

Treatment	Average Per Cent Kill Square No. 1	Average Per Cent Kill Square No. 2	Average Per Cent Kill Both Squares
D	85.18	87.75	86.46
E	84.97	85.34	85.15
B	83.27	84.43	83.85
C	80.12	83.18	81.65
F	73.08	67.61	70.34

[3] Patented mixtures.

ment F was considerably lower. Further analysis of the infestation data is made to determine whether any of the differences between treatments are significant.

There are 72 blocks in all, 12 receiving each treatment, arranged as previously described in two Latin squares. The infestation or average number of nymphs found on the various blocks during the dusting period, presented in tables 1 and 2, is used in this analysis. Using the variable square method, the correction factor is:

$$\frac{(231.37+156.25)^2}{72}=2086.79$$

The total sum of squares is the sum of the squares of the number of nymphs found on each block less the correction factor, or 2441.58, having 71 degrees of freedom. The sum of squares for rows calculated for the Latin squares:

$$\left[\frac{(41.41)^2+(39.99)^2+\cdots(40.14)^2}{6}-\frac{(231.37)^2}{36}\right]$$

$$+\left[\frac{(36.50)^2+(21.75)^2+\cdots(21.50)^2}{6}-\frac{(156.25)^2}{36}\right]=40.58,$$

having 10 degrees of freedom. Similarly the sum of squares for columns is found to be 12.17, having 10 degrees of freedom. The sum of squares for replication of squares

$$\frac{(231.37)^2+(156.25)^2}{36}-2086.79=78.37,$$

having 1 degree of freedom.

Table 4 is presented for convenience in estimating the sum of squares due to treatments.

Table 4.—Total number of nymphs found on blocks receiving the same treatment in each square, cotton flea hopper control experiments, College Station, Tex., 1935.

Treatment	Total No. Nymphs Found, Square 1	Total No. Nymphs Found, Square 2	Total No. Nymphs Found, Both Squares
A	125.14	85.50	210.64
B	19.41	12.25	31.66
C	23.13	12.75	35.88
D	18.71	12.75	31.46
E	15.99	10	25.99
F	28.99	23	51.99

The sum of squares for treatments:

$$\frac{(210.64)^2+(31.66)^2+\cdots(51.99)^2}{12}-2086.79=2165.46,$$

having 5 degrees of freedom. The interaction or the response that the treatments had in the two squares is the total treatment effect

$$\frac{(125.14)^2+(19.41)^2+\cdots(23.00)^2}{6}-2086.79=2318.60-(78.37^*+2165.46\dagger)=74.77,$$

* Sum of squares due to replication of squares. † Sum of squares due to treatments.

have $11-(1+5)=5$ degrees of freedom. The complete analysis is shown in table 5.

Table 5.—Complete analysis of variance, cotton flea hopper control experiments, College Station, Tex., 1935.

Source of Variance	Degree of Freedom	Sum of Squares	Mean Square
Total	71	2441.58	
Rows	10	40.58	4.06
Columns	10	12.17	1.22
Treatments	5	2165.46	433.09
Replication of squares	1	78.37	78.37
Interaction (Treatment-Replication)	5	74.77	14.95
Remainder or error	40	70.23	1.75

The variance for treatments is much greater than that for error, therefore treatments are a significant source of variation. The value of t for $n=40$, and a probability of .05 is 2.021. The standard error of the difference

$$\sqrt{\frac{1.75\times2}{12}}=.5401\times2.021=1.09$$

The difference between means of the number of nymphs found on the blocks of each treatment must be greater than 1.09 to be significant.

Table 6.—Table of mean and mean differences, cotton flea hopper control experiments, College Station, Tex., 1935.

Treatment	Average No. Nymphs Found	Differences in Treatments				
		A	F	C	B	D	E
A. Check Untreated	17.55		13.22	14.56	14.91	14.93	15.39
F. 300-mesh sulfur plus 2% magnesium carbonate-syncrolite (70:30)	4.33			1.34	1.69	1.71	2.17
C. 300-mesh sulfur plus 2% magnesium carbonate	2.99				.35	.37	.83
B. 200-mesh sulfur plus 2% magnesium carbonate	2.64					.02	.48
D. 300-mesh sulfur, unconditioned	2.62						.46
E. 300-mesh sulfur plus 2% lime	2.16						

Comparison of the means or average number of nymphs found on the blocks receiving the same treatment is made in table 6.

The number of nymphs found on the check blocks was significantly greater than the number found on any of the treated blocks. It will be noted that the mean differences between the average number of nymphs found on the blocks that received treatments E, D, B and C were not significant, but the mean difference between these blocks and the blocks treated with F was significant. Apparently any of the above conditioned or unconditioned sulfurs, either 200 or 300-mesh, gave about the same control for cotton flea hopper nymphs, but when syncrolite was mixed with sulfur the control was decreased.

The blocks in the Latin squares were labeled so that each block could be readily distinguished. Small stakes, designating the treatment and the number of the row, were driven at the ends of each block on the middle row. When dust applications were being applied, a diagram of the layout was carried which made it easy to find the desired blocks. Temporary flags were placed at each end of the block which made it possible to dust the correct area in a minimum amount of time.

The dusting operations on the entire square were handled by two men within a time limit of two hours. The infestation records were made in one day on all the blocks of one square, but if the number of treatments were increased the work would probably become burdensome.

It is the general practice for entomologists to use 1-acre plats with little duplication in a given year in cotton insect control tests, but it has not been possible to determine the significance of the differences between the control obtained from the various brands of sulfur by this method of experimentation. With the replications and arrangement as here discussed the significance of the differences between treatments can be determined. The analysis of the data from the 12 blocks of each treatment located at random (except the one restriction of only one block of each treatment being in each row and column) in the two fields gives a much better measure of the mean and standard deviation than the analysis of the data would give from only one large block of one treatment. In other words, the greater the number of replications the greater are the chances of obtaining reliable results. By this method of block arrangement, the variation due to heterogeneous soil and uneven distribution of insects could be eliminated, thus reducing the experimental error and increasing the value of the experiment. The analysis eliminated much guesswork in the presentation and interpretation of the data.

This work was conducted for the purpose of comparing the actual kill that was obtained from the various treatments. The final yields can be obtained on a layout of this kind, if desired, by taking the proper care at planting time to secure an even stand and by controlling other cotton insect pests that occur later in the season.—11-27-36.

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Recent Insecticide Experiments to Control Cotton Flea Hopper at Port Lavaca, Tex.

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Within the last three years several new insecticides have been tested for their toxic effect upon the cotton flea hopper, *Psallus seriatus* Reut. Most of the tests were made in cages, while a few were made in the field on growing cotton. Results of a few of the more important tests will be discussed here.

Method of conducting toxicity tests in cages.—The cages used were 18 inches square by 2 feet in height, covered with brass wire cloth. The cage proper had a bottom made of three-ply board which rested on an adjustable stool approximately 1 foot high. Cotton flea hopper nymphs were confined in cages covered with 30-mesh screen and the adults in cages covered with 24-mesh screen. Fifty insects were placed in each cage for an experiment. The insects were introduced into the cages late in the afternoon of the day preceding the beginning of the experiment. The dust applications were made early in the mornings, usually shortly after sunrise. Inspections were made of the cages at 11 a. m. and 5 p. m. on the first day of the experiment and at 8 a.m. and 5 p. m. during the following three days. At each inspection, all dead flea hoppers were removed and the number recorded. The number of living insects was recorded at the termination of the experiment, or at the end of the fourth day. In this way the exact number of insects utilized in the experiment was determined and the insect mortality that occurred in each cage throughout the four-day period of the experiment was ascertained.

In most cases 15 to 40 cages were utilized in each series of experiments and two to three cages were dusted with each insecticide used in a series. Two to four check cages were utilized for each series of dusted cages. A comparison of the mortality in the check cages with that in the dusted cages gave the kill due to the insecticide. Mortality in the check cages averaged about 12 per cent for adults and 22 per cent for the nymphs. *Croton capitatus* was used as the host plant, since the cotton flea hopper lives better on this plant than on any other suitable for such tests. An average of 404 adults was utilized for each insecticide in 1933, 225 in 1934, and 316 in 1935. The average number of nymphs used per insecticide was 220 in 1933, 170 in 1934, and 203 in 1935.

Rotenone.—Powdered derris root and cubé root, each containing approximately 4 per cent of rotenone, were tried against the flea hopper. Neither of these materials showed any promise. The kill of adults from derris root was around 4 per cent and of nymphs about 7 per cent. The cubé root gave a kill of 2 per cent of adults and no kill at all of nymphs. Derris was mixed with sulfur, 1 part to 4 parts by weight, but the mortality of both adults and nymphs was below that caused by straight sulfur. The mixture of clay with 4 per cent of rotenone showed no kill. A mixture with 50 per cent of rotenone was then applied and still there was no kill of adults and only a 2 per cent kill of nymphs. A mixture of

Table 1.—Infestation records, showing average number of flea hoppers per 100 buds, and dust application in a field-plat experiment, cut E, at Port Lavaca, Tex., 1935.

Date of Inspection	Check Plat			10 Per Cent Paris Green–Sulfur Plat			Dust Applications	
	Adults	Nymphs	Total	Adults	Nymphs	Total	Date	Pounds per Acre
May 15		54.7	54.7	.7	49	49.7	May 16	20.5
May 20	26.3	16.7	43	2.7	4.6	7.3		
May 27	23	6.7	29.7	13.3	1	14.3	June 18	15.5
June 20	44	62.7	106.7	3.3	6.4	9.7		
June 26	48	20.3	68.3	7.3	2.7	10		
July 2	12.3	6	18.3	4.3	2	6.3		
Average after dusting started	*30.7*	*22.5*	*53.2*	*6.2*	*3.3*	*9.5*		

sulfur with 4 per cent of rotenone also failed to show any benefit from the rotenone.

Phenothiazine.—This new insecticide, which is proving to be toxic to many insects, was tried against the cotton flea hopper in 1934 and again in 1935. According to analyses made in the Division of Insecticide Investigations, the material used in the field in 1934 was inferior, containing only about 55 per cent of phenothiazine, but in 1935 the material was of standard quality. The tests in 1934 with phenothiazine showed that this material gave no kill of nymphs and only 2.8 per cent kill of adults. It was used straight and also in mixtures with lime, cubé root, and clay, none of which gave any promising results.

In 1935 the toxic effect of phenothiazine in the cotton flea hopper was only slightly greater than in 1934; the kill of adults was 22.8 per cent, and there was no kill of the nymphs. A mixture of equal parts of this material with clay reduced the kill of adults to 15.8 per cent.

Pyrethrum.—A commercially prepared pyrethrum dust, said to contain an activator and .5 per cent total pyrethrins, was tested in 1934. The undiluted dust was effective in killing adults (75 per cent mortality in the dusted cages) and was fairly effective on nymphs (57.7 per cent mortality). Three home mixtures of pyrethrum and sulfur were used. The proportions were as follows: (1) a 1:1 mixture, (2) 1 part pyrethrum and 3 parts sulfur, and (3) 1 part pyrethrum and 9 parts sulfur. The

mixtures of pyrethrum and sulfur increased the kill of nymphs but decreased the kill of adults, the 1:9 mixture giving a 72 per cent kill of nymphs and 32 per cent kill of adults.

Mixtures of Paris green and sulfur.—For several years cage experiments, as well as field-plat experiments, have shown that a 25:75 mixture of Paris green and calcium arsenate killed a high percentage of adults, but was much less effective against nymphs. In the case of sulfur the reverse was true, there being a high kill of nymphs and only a fair kill of adults. In the cage experiments of 1934 the highest kill of both adults and nymphs from any of the insecticides used was from a mixture of 1 part Paris green and 5 parts sulfur, the average mortality of both stages being 82.8 per cent in the cages dusted with this mixture. Other

Table 2.—Comparison of blooms in the treated plat and the untreated plat of cut E, Port Lavaca, Tex., 1935.

Date of Inspection	No. Blooms per Acre		Per Cent Gain in Dusted Over Check Plat
	Check	10 Per Cent Paris Green–Sulfur Plat	
June 24	6	1566	26,000.
July 2	63	5163	8,095.2
July 10	222	1082	387.3
July 16	414	4242	924.6
July 22	609	2238	267.5
July 31	3858	522	−86.5

proportions of these insecticides were also used and they showed very good results. The Paris green used in all of these mixtures was of an "air-floating" type. Addition of this Paris green greatly improved the dusting quality of sulfur.

Field-plat experiments.—In 1935, three replications of field-plat experiments were conducted, using three mixtures of Paris green and sulfur, 5:95, 10:90 and 20:80. Each of the three cuts contained 4 acres; 3 acres were dusted, one with each mixture, and 1 acre was left untreated as a check. The mixture of 10 per cent Paris green and 90 per cent sulfur proved to be the best. The average gain in production from the plats dusted with this mixture was greater than from either of the other two mixtures; also the net profit per acre was greater. The 20:80 Paris green–sulfur dust gave the highest kill of the cotton flea hopper, but this mixture contained so much Paris green that it had an injurious effect upon the cotton plant. There was no injury to the cotton plant from the 5 per cent or 10 per cent Paris green–sulfur mixtures. Additional field tests were conducted late in the season on young cotton, and these tests also failed to show any injurious effects on the cotton plant with mixtures of sulfur and Paris green containing as high as 10 per cent Paris green.

One of the experiments, cut R, was located in late-planted cotton. The infestation in this cut was high when the experiment was started on June 18, but the high infestation did not last long, and consequently there was very little flea hopper damage and no gain in production from

the dusted plats of this cut. Another experiment, cut K, did not have a very high infestation at any time during the season and the gain in production from the plat dusted with 10 per cent Paris green–sulfur was only 82 pounds of seed cotton per acre.

The other experiment, cut E, was located in cotton planted early in the season, where there was a high infestation of flea hoppers when the experiment started on May 16. The infestation continued until July, thereby making conditions ideal for testing the effectiveness of the mixtures. Some of the field-plat records made in cut E, showing a comparison of the untreated plat and the plat dusted with 10 per cent Paris green–sulfur, are given here.

Table 3.—Yield of seed cotton from the treated and the untreated plat of cut E, Port Lavaca, Tex., 1935.

Date Picked	Pounds Yield per Acre		Increase in Dusted Over Check Plat	
	Check Plat	10 Per Cent Paris Green–Sulfur Plat	Pounds	Per Cent
Aug. 6	62	834	772	1245.2
Aug. 12	60	208	148	246.7
Aug. 28	344	252	−92	−26.7
Sept. 21	246	14	−232	−94.3
Total	*712*	*1308*	*596*	*83.7*

Infestation records.—Six flea hopper-infestation records were made in cut E between May 15 and July 2. Three hundred terminal buds of cotton plants were inspected per plat on each date. These records, table 1, show that a very high kill of both adults and nymphs was secured from the applications of 10 per cent Paris green–sulfur.

Fruitage of the dusted and the untreated cotton.—On July 2 the forms (squares, blooms and bolls) were counted on 300 representative plants in each plat. This inspection showed an average of .59 form per plant in the check plat and 10.08 forms per plant in the plat dusted with 10 per cent Paris green–sulfur.

The number of blooms on the 10 center rows of each 30-row plat was counted six times between June 24 and July 31. The results of these counts on the check and the dusted plat are shown in table 2.

Early harvesting in dusted plat.—The excellent control of the flea hopper, as indicated by the infestation records and form counts, is borne out by the early picking records. This cut was picked four times between August 6 and September 21, as shown in table 3.

The cotton treated with 10 per cent Paris green–sulfur produced a normal early crop. By August 12, 1042 pounds of cotton had been picked from the acre dusted with 10 per cent Paris green–sulfur in comparison with 122 pounds from the adjoining untreated acre. Eighty per cent of the cotton produced on the dusted plat was harvested by August 12, whereas only 17 per cent of that produced on the untreated plat was harvested by that time.

Two applications give control.—An outstanding feature of the flea

hopper control secured from the use of the Paris green–sulfur 10:90 mixture was that only two applications of this dust were necessary to give control throughout the season. From two to three times this number of applications are usually necessary with straight sulfur. A comparable test, located on the same farm just across a field road from cut E was conducted with straight sulfur (93–95 per cent 300-mesh). It required six applications of approximately 19 pounds of sulfur per acre-application to bring the flea hopper under control, and the gain from this dusting was 92 pounds of seed cotton less than from the 10 per cent Paris green–sulfur. The cost of labor and materials for dusting the sulfur plat was $5 per acre, as compared with $2.37 per acre with the Paris green–sulfur. The number of applications necessary to secure control is a factor of very great importance to the farmer, especially since flea hopper-control measures are usually necessary early in the season when the cotton demands a large part of the farmer's attention for cultivation.

Cost and profit from the Paris green–sulfur mixtures.—The cost of the three Paris green–sulfur mixtures was as follows: the 5 per cent mixture cost 4.1 cents, the 10 per cent mixture cost 5.2 cents, and the 20 per cent mixture cost 7.4 cents per pound. The cost of applying the dust was figured at 25 cents per acre-application. The cost of picking the seed cotton was 50 cents per 100 pounds and the cost of ginning 40 cents per 100 pounds. The lint turnout from the seed cotton was 35 per cent. The value of the lint cotton was figured at 12 cents per pound and the cotton seed at $30 per ton. In cut E, the gain in production of seed cotton per acre in the three dusted plats over the check was as follows: The plat dusted with 5 per cent Paris green–sulfur gained 398 pounds, the plat dusted with 20 per cent Paris green–sulfur gained 422 pounds, and the plat dusted with 10 per cent Paris green–sulfur gained 596 pounds. The value of this increased poundage, less the cost of picking and ginning, was: $17.02 for the 5 per cent Paris green–sulfur, $18.04 for the 20 per cent Paris green–sulfur and $25.48 for the 10 per cent Paris green–sulfur. The cost of dusting was: $2.06 per acre for the 5 per cent Paris green–sulfur, $3.09 for the 20 per cent Paris green–sulfur, and $2.37 for the 10 per cent Paris green–sulfur. After deducting all expenses, the net profit per acre in cut E from the 5 per cent, 20 per cent and 10 per cent mixtures was $14.96, $14.95 and $23.11 respectively.

Summary.—Derris root and cubé root, in cage tests, gave practically no control of the cotton flea hopper. Other mixtures containing rotenone were also ineffective in killing this insect.

Pyrethrum dust containing .5 per cent total pyrethrins was effective in killing adults (75 per cent mortality) and was fairly effective against nymphs (57.7 per cent mortality). The mixture of pyrethrum with sulfur increased the kill of nymphs but decreased the kill of adults.

Phenothiazine was not effective in killing the cotton flea hopper.

Mixtures of Paris green and sulfur, varying from 5 to 20 per cent Paris green, gave the most promising results in cage and field experiments. A mixture of 10 per cent Paris green and 90 per cent sulfur gave better control of the cotton flea hopper than any other material used in field tests in 1935. Three cuts (where only two applications were made)

produced an average gain of 220 pounds of seed cotton per acre over the checks. One experiment showed a gain of 596 pounds of seed cotton per acre from two applications of 10 per cent Paris green–sulfur, and a net profit of $23.11 per acre.—2-20-36.

Large-scale Sulfur-dusting Experiments for Cotton Flea Hopper Control at Port Lavaca, Tex.

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For a number of years most of our experiments with sulfur for the control of the cotton flea hopper, *Psallus seriatus* Reut., have been conducted on 1-acre plots. In 1935 it was decided to increase the acreage dusted in a number of experiments to determine whether the number of applications and the cost of treatment could be reduced by dusting on a field basis. Cooperative arrangements were made for Dr. F. L. Thomas, of the Texas Agricultural Experiment Station, to supply the sulfur and the farmers to furnish the dusting machines and labor for dusting and harvesting under the general supervision of the writers. The cooperation of the farmers was excellent. In most cases the owners or tenants did the dusting themselves and in only two cases was hired labor used in operating the dusting machines. By such arrangements information was secured on the practicability of flea-hopper control during May and June, at a time when much of the growers' attention is required for cultivation.

Sulfur used.—All the sulfur used in these experiments was ground so that 93–95 per cent passed through a 300-mesh screen. Two brands were used; one was 99.8 per cent pure sulfur and the other contained a $2\frac{1}{2}$ per cent conditioner. Both brands dusted satisfactorily through the large dusting machines, and there was no noticeable difference in their toxic effect upon the cotton flea hopper.

Location and size of experiments.—Ten large-scale sulfur-dusting experiments were carried through to completion in different parts of Calhoun county, Tex. The size of the dusted area on the various farms ranged from 17.5 to 76.6 acres, the average per experiment being 34.1 acres. The acreage in the treated and untreated areas of each experiment is shown in table 1. In some cases a block of cotton was split in half, one side being dusted and the other side left untreated as a check; in others, all the cotton on a farm was dusted except from five to 16 acres, the check being either on one side or in the center of the dusted area; while in others, only a third or a fourth of the field was dusted, an adjoining untreated area of equal size being used as a check. Especial care was taken in selecting the treated and untreated acreage of each experiment so that the potential production per acre was, as nearly as possible, the same.

Unfavorable weather conditions.—Too much rain during the latter part of May and the first part of June delayed dusting and materially hindered the flea hopper control that would otherwise have been possible. During the 18-day period from May 28 to June 14 inclusive, there were 10 rainy days, with a 5.33-inch rain on June 3. There was a very sharp increase of flea hoppers in most of the cotton shortly after that heavy rain. For maximum control all the cotton should have received sulfur applications during this period, but this was impossible, since the dusting machines could not be operated in the wet fields.

Table 1.—Acreage and sulfur applications in the large-scale dusting experiments at Port Lavaca, Tex., 1935.

Experiment (or Cut) No.	Acreage		Sulfur Applications				Pounds Sulfur Used per Acre	
	Untreated	Treated	Date First	Date Last	Total No.	No. Effective	Total	Per-acre Application
1	5.3	26.4	6/19	7/7	3	2¾	59.8	19.9
2	7.9	17.5	6/18	6/27	3	3	67.1	22.4
3	4.7	35.6	5/20	6/26	4	3½	58.3	14.6
4	7.7	36	6/18	7/2	3½	3	75	21.4
5	5.9	27.4	6/18	6/29	2½	2	54.7	20.5
6	16.7	76.6	6/18	6/24	2	2	45.4	22.7
7	26.3	29	6/18	6/29	3	3	55.9	18.6
8	33	32.5	5/21	7/1	4	4	60	15
9	34.5	30	6/24	7/9	3½	3	65	18.6
10	7.9	30.2	6/11	7/10	4¼	4	79.5	18.7
Total	*149.9*	*341.2*						
Average	*15*	*34.1*			*3.3*	*3*	*62.1*	*19.2*

Dust applications.—Dusting started in one experiment on May 20 and in another on May 21. All the other experiments were started in June; one on June 11, five on June 18, one on June 19, and one on June 24. Two to four effective applications were made in each cut, with an average of three. Table 1 shows the dates of the first and last applications, the number of applications, the total poundage per acre, and per-acre application of sulfur for each of the 10 experiments. An average of 62.1 pounds of sulfur was used per acre, the range being from 45.4 pounds in cut No. 6 to 79.5 pounds in cut No. 10. The average number of pounds of sulfur used per acre-application in the 10 cuts was 19.2, the minimum being 14.6 in cut No. 3, and the maximum 22.7 in cut No. 6.

The machines used in distributing the dust were all team-drawn five-row dusters except two. There was one three-row duster used on cut No. 5, and one 10-row tractor duster used on cut No. 8. Five of the machines were new or less than 1 year old, one was 2 years old, and four were around 5 years old. All the machines handled or distributed the sulfur in a satisfactory manner. However, the three-row machine, which was used on cut No. 5, had several breakdowns, which hindered making the applications at the right time. This cut received the poorest applications of any in the series.

In most instances weather conditions were fairly favorable at the time of dusting. Most of the dusting was done between midnight and 7 a.m., or while the dew was on the cotton. In several instances, however, ma-

chines were operated until 10 a.m. with very good results. In making the applications every row of cotton was covered with a nozzle each time.

There was an unusually early and prolonged infestation of leaf worms this year. Calcium arsenate was used in controlling this insect on all except one cut (No. 9) which was sprayed four times with lead arsenate for leaf worm control. The other nine cuts were dusted with calcium arsenate for leaf worms four to six times between July 1 and August 10. These applications also reduced the boll weevil damage and aided materially in producing a late crop, especially in the check portions of the sulfur experiments.

Table 2.—Infestation records made in large-scale sulfur-dusting experiments showing number of flea hoppers per 100 buds before dusting started and effect of the sulfur on the flea hopper. Port Lavaca, Tex., 1935.

Experiment (or Cut) No.	Inspection Just Prior to First Application		Average No. After Dusting Started*					
	Check	Treated	Check			Sulfur Dusted		
			Adults	*Nymphs*	*Both*	*Adults*	*Nymphs*	*Both*
1	42	46	12.7	18.7	31.4	13.5	2.5	16.
2	66	52	12.3	11.8	24.1	6.4	3.3	9.7
3	32	24	14.9	30	44.9	10.4	15.4	25.8
4	66	61	16.5	45.8	62.3	23	3.2	26.2
5	24	27	26.1	23.2	49.3	16.7	5.2	21.9
6	125	118	6.8	13.7	20.5	4.4	1.3	5.7
7	81	77	15.2	17.8	33	4.5	2.2	6.7
8	23	31	14	14.9	28.9	10.1	1.9	12
9	58	65	22.9	7	29.9	16	.9	16.9
10	77	82	13.5	100	113.5	12.2	12	24.2
Average	*59.4*	*58.3*	*15.5*	*28.3*	*43.8*	*11.7*	*4.8*	*16.5*

* Average of five inspections in cut No. 3, three in cut No. 8, and two in all others.

Infestation.—Flea hopper-infestation records were made in all the cuts around the middle of May. These records consisted in inspecting 300 main-stem terminal buds in each of the treated and untreated areas and recording the number of live adult and nymphal flea hoppers. They showed that only two cuts had a high enough infestation by the middle of May to warrant control measures. These cuts, Nos. 3 and 8, were dusted May 20 and 21 respectively. The infestation gradually increased until by the latter part of May and the first part of June there was a high infestation in practically all the cuts. As explained elsewhere, however, the dusting could not be started or resumed at this time owing to excessive rains.

Table 2 shows a summary of some of the infestation records made in the different cuts. The infestation records made in the 10 cuts just prior to the first application of dust showed an average of 59.4 flea hoppers (adults and nymphs) per 100 buds in the check areas and 58.3 in the areas to be dusted. This infestation ranged from a minimum of 23 in cut No. 8 on May 20 to 125 in cut No. 6 on June 14.

The infestation records made after dusting started showed that the sulfur gave good control of the nymphs but very little control of the adults, the average nymphal population in the dusted areas being 4.8 per 100 buds, while in the untreated areas the average was 28.3, or six times as many nymphs in the untreated as in the treated areas. There

was only a slight reduction in the adult population, the average in the untreated areas being 15.5 and in the treated areas 11.7 per 100 buds.

Gain from dusting.—The production of seed cotton from the entire treated and untreated acreages of each experiment was weighed. Table 3 shows the production on a per-acre basis from each experiment. The average poundage gain was 167.5 pounds per acre.

In figuring the profit from the dusting operations the following basis was used: Sulfur at 3 cents per pound, cost of applying the sulfur at 25 cents per acre application, cost of picking at 50 cents per 100 pounds,

Table 3.—Yield of seed cotton per acre from the large-scale sulfur-dusting experiments and net profit as a result of dusting. Port Lavaca, Tex., 1935.

Experiment (or Cut) No.	Yield per Acre		Grain per Acre Treated Over Untreated		Net Profit per Acre from Dusting Operations
	Untreated	Treated			
	pounds	*pounds*	*pounds*	*per cent*	
1	348.1	656.9	308.8	88.7	$10.66
2	617.3	959.2	341.9	55.4	11.86
3	454.8	744.6	289.8	63.7	9.64
4	482.2	705.4	223.2	46.3	6.41
5	567.7	503.2	−64.5	−11.4	−2.30
6	581.7	659	77.3	13.3	1.44
7	590.4	684.9	94.5	16	1.61
8	759.5	1003.5	244	32.1	7.63
9	470.6	497	26.4	5.6	−1.70
10	391.9	525.8	133.9	34.2	2.27
Average	*526.42*	*693.95*	*167.53*	*34.3*	*$ 4.75*

cost of ginning at 40 cents per 100 pounds, value of the lint at 12 cents per pound, seed at $30 per ton, and 35 per cent lint in seed cotton. The average cost of dusting was $2.69 per acre, the maximum being $3.45 on cut No. 10 and the minimum $1.86 on cut No. 6. Two cuts, Nos. 5 and 9, showed a net loss per acre of $2.30 and $1.70 respectively, table 3. The others showed a net profit per acre, the highest being $11.86 and the lowest $1.44. The average net profit was $4.75 per acre.

Comparison with 1-acre sulfur-treated plots.—Sixty 1-acre field-plot experiments were conducted in Calhoun county in 1935. Several insecticides or combinations of insecticides were used, but 24 1-acre plots were dusted with sulfur. While these dusting experiments are not strictly comparable with the large-scale dusting experiments, a comparison will give some idea of the advantage from dusting on a large scale. The 24 1-acre plots received an average of 5.7 applications of sulfur, the range being from a minimum of three to a maximum of eight applications. This is compared with an average of 3.3 applications on the large-scale dusting experiments. The average cost of dusting the 1-acre plots was $4.33 per acre, as compared with $2.69 for the large-scale experiments. The gain from the 24 1-acre plots was 127.8 pounds of seed cotton per acre, and from the 10 large-scale dusting experiments 167.5 pounds per acre. The net profit from the 24 1-acre plots was $1.40 per acre, as compared to $4.75 per acre from the large-scale dusting experiments.

Summary.—Fields of cotton ranging in size from 17.5 to 76 acres were dusted with sulfur for flea hopper control on 10 farms in Calhoun county, Tex., in 1935. Adjoining untreated areas were left on each farm for comparison. On account of heavy rains early in June, only two of the experiments were started early enough to secure maximum control.

Two to four effective applications of sulfur were made. The average amount of sulfur used per acre was 62.1 pounds. The cost per farm ranged from $1.86 to $3.45 per acre, the average being $2.69 per acre.

Average gain in production from the sulfur dusting in the large-scale experiments was 167.5 pounds of seed cotton per acre. This showed an average net profit of $4.75 per acre from the sulfur dusting. The highest profit on any farm was $11.86 per acre.

Twenty-four 1-acre field plots were dusted with sulfur in 1935. An average of 5.7 applications were needed as compared with 3.3 applications in the large-scale experiments. The average gain in yield on the 1-acre plots was 127.8 pounds of seed cotton per acre and the average profit was $1.40 per acre, as compared with 167.5 pounds gain and an average profit of $4.75 per acre from dusting on the large-scale tests.—2-20-36.

PACIFIC SLOPE BRANCH

PAPER-READING SESSION, TWENTY-FIRST ANNUAL MEETING

Seattle, Wash., June 1936

The Cotoneaster Webworm, *Cremona cotoneaster* Busck[1]

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These observations on a new species of gelechiid moth attacking the ornamental shrub *Cotoneaster horizontalis* were made at Portland and Corvallis, Ore., in the seasons of 1933 and 1934. The insect has been recently described by August Busck, Division of Insect Identification, U. S. Bureau of Entomology and Plant Quarantine, as a new species in a new genus under the name of *Cremona cotoneaster*. Busck (*1*) suggested that the insect may be of Asiatic origin since *Cotoneaster horizontalis* is an introduced plant from China.

History in the northwest.—Apparently the first evidence of this insect in the northwest came to Dr. Don C. Mote when specimens of cotoneaster damaged by the insect were received by him from Eugene, Ore., May 18, 1929, and from Portland on June 4, 1929. Mr. W. W. Baker, junior entomologist, Division of Truck Crop and Garden Insects, U. S. Bureau of Entomology and Plant Quarantine, in 1930 reported that he observed infested shrubs in Portland.

[1] Family Gelechiidae, Order Lepidoptera.

[2] Published as technical paper 247 with the approval of the Director of the Oregon Experiment Station. Contribution of the Department of Entomology.

At present the insect is known to occur in Corvallis, Salem, Portland, and other locations in Multnomah county. Letters from Eugene, Jennings Lodge and Winchester, Ore., indicate its presence. Several infestations also have been observed at Vancouver, Wash. During 1934, cotoneaster plantings were examined in several western Oregon cities and no webworm infestations were found except in the localities mentioned.

The number and severity of the infestations have increased since 1930. Many plantings in Portland were uninfested in 1930, whereas very few uninfested shrubs could be found in 1934. At Corvallis, where the insect has been present for at least six years, some of the plantings are heavily infested; others only slightly infested, and some with no infestation.

Life history.—Egg deposition begins the latter part of June and extends into July. The eggs are laid singly or in pairs on various parts of the host plant, old leaves, green leaves, stems, and even in old webbings. The yellow oval eggs are approximately .5 mm. long and .3 mm. wide.

The small larvae, which are yellowish, generally appear during the latter part of June, July and the first part of August. These caterpillars construct small silken tubes extending out from a larger silken case which might be termed the refuge base. The latter is usually located in the junction of a small branch with a larger stem of the plant. The tube from the refuge base extends to the leaves in which the larva feeds.

The caterpillars make a rapid growth in spring and early summer. It is then that they do their greatest damage to the host plant both by their voracious feeding and extending of their unsightly webbings.

The mature larva is about a centimeter in length and brownish black. When feeding upon the surface of a leaf, the head of the larva is extended partially out of the silken tubes. The larva moves rapidly backward to the refuge base upon a slight disturbance of the bush or often upon the sudden approach of an observer.

During the winter months, the caterpillars remain most of the time in the refuge base which serves as a hibernaculum. Occasionally they leave the refuge base on warm days in winter and crawl up the feeding tubes to the leaves on which they feed. Prior to pupation, which occurs in late spring and early summer, a silken case is spun on the outside of the refuge base. The caterpillar pupates in the refuge base which is further strengthened just before pupation takes place.

The adult moths emerge about two weeks after the pupal case is formed. They are about 5 mm. long and grayish black. The adults are active at night and are frequently attracted to lights. During the day moths are usually found on the under sides of leaves or on inner leaves of *Cotoneaster horizontalis*, apparently not very active. The only mating pair of moths observed was on a cloudy day at 9:30 a.m., July 18, 1933.

The chalcid *Spilochalis albifrons* (Walsh) was reared on several occasions from the pupae of the *C. cotoneaster*. This insect does not appear to affect greatly the numbers of the webworm, for only 12 of these parasites developed from large numbers of collected pupae in 1933 and 1934. The larvae and pupae of the webworms in their feeding tubes and refuge bases appear to be well protected from most parasites and predacious insects as well as from birds.

Effect upon the host.—The leaves are skeletonized by the caterpillars which feed upon the upper and lower surfaces. In some locations in which the infestations have been heavy for a number of years, severe damage by continued yearly defoliation has resulted in many devitalized plants in which little new growth takes place. In some instances plants have died. Shrubs which have not been seriously devitalized frequently make noticeable leaf growth in summer after the overwintering caterpillars have ceased feeding and have pupated. The webbing habits of the larvae have resulted in many unsightly plants, causing some home owners to destroy their plantings.

Control.—The webworm apparently is readily controlled by either contact or poison sprays such as lead arsenate, nicotine sulfate and a rotenone-bearing dust. Thorough coverage and proper timing are important. The habit of the caterpillars of feeding upon either the upper or lower surfaces of the leaves necessitates a spray or dust coverage on both sides of the foliage. Also, the habit of the caterpillars of retreating into the refuge bases upon the slightest disturbance requires that the under sides of the branches be thoroughly covered when a nicotine sulfate spray is used.

The most satisfactory time for the application of any of these sprays appears to be in late summer or early fall. At this time all eggs have hatched and there will be no reinfestation until the next summer. Effective control, however, may be obtained any time the larvae are active and feeding. Sprays or dusts applied in late spring and early summer are not as effective as in late summer or fall, although they may appear to be so, for there is generally a marked new growth of *Cotoneaster horizontalis* following the time that the webworms cease to feed.

Lead arsenate spray was applied at the rate of 3 teaspoons of lead arsenate, 1 cup of skimmed milk, and water to make 1 quart. Satisfactory results were obtained with this spray material when applied with a small hand sprayer of the type used by many householders in insect control about homes. The lead arsenate-spray residue remains on the leaves of the plant for some time, but this can be washed off with water from a garden hose a few days following the spray application.

Nicotine sulfate, 40 per cent, was found to be effective in killing these webworms without any injury to the host plant. This material was applied at the rate of 1:600 in a small household hand sprayer during the warm portion of the day.

A derris dust applied to the infested shrub with a large salt shaker gave good control. This dust was prepared by mixing 1 part derris (rotenone 5 per cent) with 9 parts of hydrate of lime. This mixture did not kill the caterpillars quickly but in a week's time the majority of the webworms were dead. After the caterpillars died from the effects of this dust, water from a garden hose was used to wash the material from the plant.—9-21-36.

Literature Cited

(*1*) **Busck, August.** 1934. A new genus and species of the family Gelechiidae (Lepidoptera). Proc. Ent. Soc. Wash. 36(4):82–5. 5 figs.

The Field Cricket as a Pest of Strawberries and Its Control

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Growers of strawberries in North Carolina have suffered appreciable losses during the last 10 years through the depredations caused by black field crickets, *Gryllus assimilis* (Fab.). In the Chadbourn area hardly a field has entirely escaped some damage from this pest. With its long growing season the strawberry plant furnishes abundant food throughout the year, and the cultural methods of some growers provide the crickets with ideal protection from the heat of summer and the cold of winter. Under these conditions, also, predacious enemies are handicapped, with the result that enormous populations of crickets are built up in the fields during fall and winter prior to spring fruiting.

Table 1.—Comparison of baits and poisons for killing field crickets during the first two days, in terms of percentage mortality.

	Corn Meal	Wheat Middlings	Wheat Middlings and Cotton-seed Meal	Chick Mash	Cotton-seed Meal	All Baits
Sodium fluosilicate	100	100	100	100	100	100
Sodium fluoride	95	95	85	95	95	93
Barium fluosilicate	100	95	95	90	85	93
Calcium arsenate	90	65	90	90	80	83
White arsenic	65	90	95	65	100	83
Derris		80	90	80	50	75
Paris green	80	40	60	50	45	55
All poisoned	88	81	88	81	79	
Unpoisoned	50	0	50	0	15	23

The injury caused by this cricket is by no means confined to the southern strawberry-producing areas. Reports from the eastern seaboard states as far north as New York indicate that it is prevalent in destructive numbers and is a potential pest wherever strawberries are grown.

Nature of injury.—Strawberry plants are subject to the attacks of the field cricket at almost any time during the life of the plant. However, the most serious injury to the plants occurs in the fall when runner plants are forming. As the runners grow out from the mother plant, the outer bark is gnawed away and the runners are killed. Very often a young plant has already developed at the end of the runner, but not yet rooted, and this too is killed. Occasionally, where the cricket population is large, almost no new plants are set, which makes it necessary for the grower to purchase plants elsewhere for replacing missing ones and for setting new

acreage. Leaf petioles are attacked in a similar way, but the injury from this source is negligible under ordinary conditions.

By far the most serious commercial loss occasioned by the cricket occurs early in the spring from the time the plants begin blooming until the ripe berries are harvested. The method of mulching the plants with pine needles late in the winter not only furnishes excellent protection for the crickets from unfavorable weather conditions and predacious enemies, but also serves to concentrate the insects in close proximity to the plants. Here they feed on developing fruit buds, open blossoms and fruit in all stages. Both buds and blossoms are often completely destroyed and the immature fruit is gnawed to such an extent that it develops into a knotty dwarf berry unfit for marketing. The injured areas usually

Table 2.—Comparative effect of three-day-old bait and fresh bait on field crickets, in percentage mortality during the first three days.

	Wheat Middlings and Cottonseed Meal		Wheat Middling		Chick Mash		Cottonseed Meal		All Baits	
	Old	New	Old	New	Old	New	Old	New	Old	New
Sodium fluosilicate	100	100	100	100	100	100	100	100	100	100
Sodium fluoride	85	100	100	95	100	95	90	90	94	95
Barium fluosilicate	95	100	95	95	90	85	85	90	91	92
White arsenic	85	95	75	95	95	85	90	90	86	91
Paris green	100	75	95	90	70	90	70	75	84	82
All poisons	93	94	93	95	91	91	87	89		
Check (unpoisoned)	55	40	50	55	15	40	40	65	40	50

heal over, but the fruit can never be salable. When the ripe fruit is attacked, the injury is much more apparent, and extreme care must be exercised by the packer because these injured berries, if packed along with marketable fruit, will begin leaking within a few hours and cause rapid deterioration of all the fruit in the individual container.

Tests of toxicity in cages.—Because of the increasing activity of the field crickets in the strawberry fields and the increasing number of complaints from growers, it was deemed advisable to obtain data on the relative effectiveness of various poisoned baits for field cricket control. The baits tested were wheat middlings, cottonseed meal, equal parts of wheat middlings and cottonseed meal, corn meal, and chick mash. The last was composed of a mixture of various grains, alfalfa, meat scrap and dried buttermilk. The poisons used were derris, white arsenic, Paris green, sodium fluoride, sodium fluosilicate, barium fluosilicate and calcium arsenate, mixed at the rate of 10 pounds of bait (except that calcium arsenate was mixed at the rate of $12\frac{1}{2}$ pounds to 100 pounds). Enough molasses solution (1:9) was added to moisten the mass.

Three series of toxicity tests were conducted in the laboratory. The cages used were cylindrical, 12 inches in diameter and 12 inches high, the open top being covered with cheesecloth. The baits were placed in open salve tins in the cages and 20 active crickets, just brought in from the field, were put in each cage. Checks containing baits with molasses solution but no poison were employed in all tests. Examinations were made at 24-hour intervals for two days in the first test, and for three

days in the second and third. The second series differed from the others in that it compared three-day-old bait with fresh bait. The results of the tests are given in tables 1, 2 and 3, respectively. To conserve space, only the final results are given, except in table 3 for the third series.

The results of the cage tests would seem to indicate that there was no outstanding difference in the effectiveness of the various bait materials. Judging by the last series, sodium fluosilicate exhibited the greatest toxicity, closely followed by calcium arsenate, the other fluorine compounds, and white arsenic. Paris green and derris appeared to be somewhat less toxic. The use of the three-day-old material, which had begun

Table 3.—Comparative rapidity of killing effect on the field cricket of various poisons in different baits in terms of percentage mortality.

	Corn Meal			Wheat Middlings			Chick Mash			Cottonseed Meal			All Baits		
	1 Day	2 Day	3 Day	1 Day	2 Day	3 Day	1 Day	2 Day	3 Day	1 Day	2 Day	3 Day	1 Day	2 Day	3 Day
Sodium fluosilicate	60	100	100	70	100	100	100	100	100	75	100	100	76	100	100
Calcium arsenate	60	90	100	20	65	90	35	90	100	30	80	95	36	81	96
Sodium fluoride	35	95	95	35	85	100	40	90	95	60	90	90	43	90	95
Barium fluosilicate	80	100	100	50	80	95	55	80	85	40	70	90	56	82	92
White arsenic	10	65	85	60	90	90	20	65	90	85	100	100	44	80	91
Paris green	15	65	75	15	40	75	15	50	70	10	45	70	14	50	72
Derris				5	25	45	20	30	50	20	50	65	15	35	53
All poisons	43	86	92	36	69	85	41	72	84	46	76	87			
Check (unpoisoned)	15	50	75	0	15	50	10	35	40	5	30	40	7	32	51

to ferment, in comparison with freshly mixed bait, failed to reveal any significant difference in killing value. The fluorine compounds, particularly sodium fluosilicate, were much quicker in their action than were the arsenicals. In some of the check cages the cricket mortality was very high. This can probably be accounted for to some extent by the extreme cannibalistic habits of the insects.

Field control.—On the basis of the results obtained from the toxicity tests made in the laboratory, a control experiment was laid out in the field with two of the most promising toxic agents, barium fluosilicate and calcium arsenate, mixed with corn meal. The strawberry field selected for the experiment covered about one-half acre, and harvesting had already begun. The area was divided, for a duplicate series of treatments, including the checks, into eight plots of eight rows each.

At the time of the treatment, April 25, 1933, the plants were very vigorous and were fruiting heavily, but the injury from crickets was so severe that practically no marketable fruit was being harvested. The plants had been mulched heavily with pine needles, and these afforded ideal protection for the crickets, which were abundant and well distributed over the field. The baits were sprinkled, late in the afternoon, on one side of each row at the approximate rate of 40 pounds per acre.

The bait was prepared according to the following formula:

Calcium arsenate (or barium fluosilicate)...1 part by weight
Corn meal.....20 parts by weight
Molasses and water to moisten.

Examinations were made on 63 feet of row in each plot on May 4, or nine days after treatment. The results of these examinations are shown in table 4.

The results of this field test indicate that either of the poisons, in combination with corn meal, molasses and water, is satisfactory for controlling field crickets in strawberry fields at the time of harvest.

The mixture containing calcium arsenate has been used frequently by growers since the test was made, and they report that highly satisfactory results have been obtained.

Table 4.—Results of poisoned bait applications for field cricket control on strawberries.*

Treatment	No. Live Crickets on 63 Feet of Row		No. of Freshly Eaten Berries on 63 Feet of Row	
	First Replication	Second Replication	First Replication	Second Replication
Calcium arsenate	0	0	0	0
Unbaited check 1	8	5	13	60
Barium fluosilicate	0	0	0	0
Unbaited check 2	1	5	18	18

* Crickets and freshly eaten berries were found most frequently on the side of the check farthest away from the poisoned baits. An examination was made 36 hours after application, and a few dead specimens were found in the middle of the rows on the baited areas.

Summary.—The field cricket is a potential pest in the majority of the strawberry-producing areas in the eastern states. In the North Carolina area it is responsible for a large percentage of the unmarketable berries that are found in the fields heavily infested by this insect. In addition, this pest often decreases the yield of fruit by feeding on the runner plants and on the developing fruit bud and blossoms.

This insect may be controlled economically by the judicious use of poisoned baits during the early fruiting period or just prior to harvesting.

The choice of poisons will depend on their availability, but calcium arsenate, sodium fluosilicate and barium fluosilicate have given slightly better results than some of the other generally used insecticides.

The choice of baits also will depend largely on their availability. In the south, corn meal is usually available on practically every farm and is probably the most economical material to use in this area.—12-24-36.

Homologs of Paris Green

III. Members of the Oleic and Linoleic Acid Series

Frederick E. Dearborn, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Homologs of Paris green have been prepared from the principal acids of the acetic series (Dearborn 1935, 1936). No references could be found in the literature to similar compounds in which acetic acid had been re-

placed by any of the acids of the oleic and linoleic series. Since these acids are related to the acids of the acetic series, it was thought probable that such compounds could be made. Three acids, namely crotonic, oleic and erucic, were selected to represent the lower, intermediate and higher members of the oleic series. It was assumed that if homologs of Paris green could be made from them, all the acids of the series would behave similarly. Lineoleic acid was the only member of its series experimented with. Compounds containing various proportions of copper arsenite and copper soap were made from these acids.

Table 1.—Analyses of oleic and linoleic acid homologs of Paris green.

Compound	Value	Before Purification		After Purification	
		Per Cent Total Arsenic as As_2O_3	Per Cent Total Copper as CuO	Per Cent Total Arsenic as As_2O_3	Per Cent Total Copper as CuO
Copper crotonoarsenite ($3CuAs_2O_4 \cdot CuC_2H_3O_4$)	Max.	53.72	30.76	53.94	30.66
	Min.	53.17	30.22	53.17	29.97
	Ave.	53.45	30.42	53.61	30.41
	Theory			55.69	29.85
Copper oleoarsenite ($3CuAs_2O_4 \cdot CuC_{18}H_{33}O_4$)	Max.	38.04	25.99	40.71	22.98
	Min.	12.11	15.35	40.16	21.84
	Ave.			40.42	22.56
	Theory			40.71	21.82
Copper erucoarsenite ($3CuAs_2O_4 \cdot CuC_{44}H_{81}O_4$)	Max.	31.48	27.99	37.36	23.58
	Min.	8.84	14.71	36.88	23.16
	Ave.			37.14	23.38
	Theory			37.80	20.26
Copperlinoleoarsenite ($3CuAs_2O_4 \cdot CuC_{18}H_{31}O_4$)	Max.	30.08	43.55	36.65	21.84
	Min.	14.10	15.37	36.21	21.17
	Ave.			36.43	21.50
	Theory			40.74	21.88

Methods of analysis.—The methods of analysis employed were based upon those of the Association of Official Agricultural Chemists (1935). The total arsenic was determined by the hydrazine sulfate–sodium bromide distillation method, and the copper was determined by the thiosulfate method on the residue remaining after the arsenic distillation. The fatty acid was not determined.

Analyses of the samples before and after final extraction are given in table 1.

Copper crotonoarsenite.—Crotonic acid crystallizes in fine woolly needles or in large plates, melting at 72° C. It is soluble in 12 parts of water at 20° C, and in ether, alcohol and carbon tetrachloride. Five samples of the copper crotonoarsenite compound were prepared from technical crotonic acid, commercial sodium arsenite and C.P. cupric chloride by the general method described in the previous paper of this series (Dearborn 1936). Since copper crotonate is soluble only in dilute hydrochloric acid, the samples were allowed to stand several days in the acid mother liquor before being filtered. They were well washed and dried at 100° C.

As indicated in table 1, the arsenic content was lower and the copper content higher than the theoretical values for the compound analogous to Paris green. The samples were therefore extracted with carbon tetrachloride for five to six hours in the manner described in the previous

paper, to remove soluble impurities. This extraction, however, did not bring the composition much nearer to the theoretical. The samples were again allowed to soak in a warm dilute 1:20 hydrochloric acid solution for four to five hours to remove copper crotonate, then filtered, washed, dried and again extracted with carbon tetrachloride, without appreciably increasing their purity. The arsenic content was still too low, and the copper content still slightly higher than required by theory for a compound with molecular combining ratio of $4CuO:3As_2O_3$, as in Paris green. The combining ratio was, however, as close to 4:3 as to 3:2, and the departure from the theoretical can be explained on the assumption that the final material consisted of 96.3 per cent crotonoarsenite, 3 per cent copper crotonate, and .6 per cent copper oxide, the last two substances being impurities that are difficult to remove completely. It is believed from the foregoing that a definite compound was formed and that the molecular combining ratio was $4CuO:3As_2O_3$.

Copper oleoarsenite.—Oleic acid occurs as a glycerol ester in nearly all vegetable and animal fats and oils. It is obtained in large quantities as a by-product in the manufacture of stearic acid. The acid is soluble in alcohol, ether and carbon tetrachloride. The copper salt melts at about 100° C and is soluble in alcohol, ether and carbon tetrachloride. Five samples of copper oleoarsenite were prepared from technical oleic acid and the same reagents as used in preparing the crotonic compound. The samples were dried below 100° C to prevent fusing, and then extracted with carbon tetrachloride to remove excess copper oleate and other fatty matter. It appears probable from the analyses of the extracted samples that a definite compound had been formed and, further that the combining ratio was $4CuO:3As_2O_3$, the same as in Paris green. The composition of the purified product calculated from the average analysis is 99.9 per cent copper oleoarsenite with a small amount of copper oxide.

Copper erucoarsenite.—Erucic acid occurs as a glyceride in rapeseed, mustard and grape-seed oils. The acid crystallizes from alcohol in long, fine needles, melting at 33–34° C, and resembles oleic acid in its properties. It is soluble in ether and carbon tetrachloride. The copper salt is soluble in ether and carbon tetrachloride, but sparingly so in alcohol. Four samples of copper erucoarsenite were prepared from technical erucic acid, the other ingredients being the same as previously used. The samples were dried at 100° C. They were purified by extraction with ether and then with carbon tetrachloride to remove soluble matter, and analyzed.

It will be observed that in the average analyses of the purified samples the arsenic content is a trifle low and the copper content too high for a compound containing copper and arsenic in the combining ratio of $4CuO:3As_2O_3$. The calculated composition of the extracted samples corresponds to 98.3 per cent copper erucoarsenite and 3.5 per cent CuO. The excess copper content is probably due to some oxidation product of the erucic acid not destroyed by digestion with nitric acid, which liberated iodine from the potassium iodide in the determination of copper. There is no doubt about the formation of a definite compound, and it is believed that the combining ratio is very close to $4CuO:3As_2O_3$.

Copper linoleoarsenite.—Linoleic acid occurs in considerable proportions in drying and semidrying oils. It is a yellowish fluid, soluble in alcohol, ether and carbon tetrachloride; it absorbs oxygen rapidly from the atmosphere, forming a solid resinous substance insoluble in ether. The copper salt is soluble in ether and less soluble in carbon tetrachloride. The metallic linoleates absorb oxygen more readily than the free acid. Three samples of copper linoleoarsenite were prepared from technical linoleic acid, the other reagents being the same as previously used. The method of preparation was that used for the other compounds described. The samples were dried at 100° C. They were extracted with ether and then with carbon tetrachloride to remove soluble impurities, and analyzed.

The average arsenic content of the purified samples is more than 3 per cent lower than the theoretical value required by a compound containing $4CuO:3As_2O_3$, and the copper content is slightly less than .4 per cent too low. The copper linoleate undoubtedly is in an oxidized and insoluble form and not readily removed by extraction with ether or carbon tetrachloride. It is evident that a compound has been formed and the combining ratio of copper oxide to arsenious oxide is close to 4:3. The fact that copper linoleate readily absorbs oxygen from the atmosphere undoubtedly accounts for the divergence from the theoretical composition. The calculated composition from the average analyses of the purified samples for a compound containing $4CuO:3As_2O_3$ is 89.5 per cent copper linoleoarsenite, 10 per cent copper linoleate and .5 per cent copper oxide.

Toxicity.—The Bureau of Entomology and Plant Quarantine has made a few toxicity tests with the copper oleoarsenite insecticide, but no tests on the other homologs have been made. The results will be incorporated in a separate report.

Conclusions.—Crotonic, oleic and erucic acids of the oleic series, and linoleic acid of the linoleic series of fatty acids form definite complex compounds with copper and arsenic.

The combining ratio of copper oxide to arsenious oxide is probably 4:3, the deviation from the theoretical value probably being due to the difficulty in purifying the compounds.

From these conclusions the inference may be drawn that all the acids of the oleic and linoleic series of fatty acids form complex compounds of the general formula $3CuAs_2O_4 \cdot CuO$ (acid anhydride), similar to Paris green.—12-30-36.

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Laboratory Propagation of *Compsilura concinnata* Meigen

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General observations on the species.—*Compsilura concinnata* Meigen is one of the most important tachinid parasites imported into the United States. Originally introduced into New England from Europe as an enemy of the gypsy moth, *Porthetria dispar* L., and the brown-tail moth, *Nygmia phaeorrhoea* Don., this species has now attained a position second to that of no other recorded tachinid in so far as variety of host species is concerned. According to Schaffner (1934) it has been recovered from 129 identified and a few unidentified species of Macrolepidoptera, three species of Microlepidoptera, and six species of Tenthredinoidea. The species is firmly established throughout New England and has extended its range westward to points well into central New York and eastern Pennsylvania, and southward to Mount Holly, N. J. Because of its effectiveness and the wide diversity of host species it has been introduced into other parts of the country. A few of these introductions have proved successful, but others appear to have failed. Since establishment is dependent largely upon a favorable time of liberation, the need of a means of supplying material at the proper time led to its laboratory propagation. Heretofore *Compsilura* for introduction purposes has been obtained from collections of larvae of the gypsy moth, the satin moth, *Stilpnotia salicis* L., and the brown-tail moth. Undoubtedly a much larger number of *Compsilura* can be obtained with less effort in this way than by propagation, but since its recovery is limited to the time of field appearance of the hosts it is obviously not properly timed to meet all requirements.

Compsilura concinnata usually has three or four generations a year. The progeny of the second and third generations either issue or pass the winter as first, or, most commonly, second-instar maggots in various species of lepidopterous pupae. Development of the over-wintering forms is completed in the spring, and the adults (first generation) issue during the latter part of May or early in June. The gestation period is about five or six days, larval development requires eight to 12 days, and the length of the pupal stage is usually 12 to 14 days. At the end of the season the larval and pupal stages are of longer duration. Adults live well in confinement and frequently attain an age of 40 days or more. The species is larviparous, and its reproductive capacity is believed to be about 100 larvae per female.

Equipment and methods of laboratory propagation.—The mating cages in use at the laboratory are about 8 by 8 by 14 inches. They have wooden frames covered with white cotton cloth on all sides except the back, which is provided with a glass pane that will slide in either direction.

[1] The writer is indebted to C. W. Collins, in charge of the Bureau of Entomology and Plant Quarantine laboratory formerly at Melrose Highlands, Mass., and to the members of the staff, particularly T. H. Jones, P. B. Dowden and W. L. Baker, also to R. W. Brubaker for assistance during the season of 1932.

Compsilura is easily mated, and since coition usually lasts for an hour or more the removal of the mated pairs does not require the prompt attention necessary for some other tachinids. The paired flies are taken from the cage by means of a glass shell vial, into which they will crawl when slightly disturbed. The flies are allowed to remain in the vial until they separate, when the males are returned to the mating cage.

The mated females are held in wooden boxes measuring 4.2 by 6.2 by 9.2 inches, each of which will hold 50 flies without crowding. These boxes are provided with sliding glass covers and have at their front end a circular opening 2 inches in diameter through which the food and the material to be parasitized are admitted. This opening is closed with a cork stopper. When not in use the stock material is retained in the cold room at a temperature of about 60°. The flies are fed daily a solution of 1 part honey to 4 parts water on a small piece of sponge.

For parasitization work five or six flies per box can be handled most conveniently. When more are used, the work becomes confusing and much superparasitization results. A single larviposition is sufficient for parasitization, although frequently a caterpillar will receive several parasite larvae before it can be removed. This is not detrimental, since each host caterpillar is capable of supporting two or three parasite larvae; although if host material is plentiful there is no advantage in superparasitization. The caterpillars are introduced either with a long camel's-hair brush or with 10-inch forceps. As soon as the flies begin to show an unwillingness to larviposit, best results are obtained by allowing them to rest for the remainder of the day and using fresh flies. Parasitization by hand is slow work, and even under the most favorable conditions it is doubtful whether one man can effect parasitization of more than 300 individuals in an eight-hour day.

An attempt was made to hasten reproduction by confining 25 or more host larvae in a cloth cage measuring 14 by 16 by 36 inches and then introducing several *Compsilura* adults. Good results were obtained in some cases. For example, five parasites confined with 50 larvae of the forest tent caterpillar, *Malacosoma disstria* Hbn., produced 147 puparia. Less successful was the attempted parasitization of 1450 larvae of the eastern tent caterpillar, *M. americana* Fab., which proved only about 25 per cent effective. In most instances parasitization by this method proved less dependable than by hand. As a rule the puparia recovered were small, owing to superparasitism, and most of the flies died long before their supply of young was exhausted.

Results of propagation experiments.—The propagation experiment was started July 22, 1932, with puparia of the second generation out of *Nygmia phaeorrhoea* and *Porthetria dispar*. From this material 129 females were mated, and their progeny, developed upon a variety of hosts, *Bombyx mori* L., *Hamadryas antiopa* L., *Porthetria dispar*, L., *Hemerocampa leucostigma* S. & A., *Cingilia catenaria* Dru., *Hydria undulata* L., *Melalopha inclusa* Hbn., *Epargyreus tityrus* Fab. and *Schizura concinna* S. & A., totaled 1090 individuals. Subsequent parasitization during August and September of 5001 overwintering host larvae, *Euchaetias egle* Dru., *Ascia rapae* L., *Hyphantria cunea* Dru., *Halisidota*

caryae Harr., *Papilio troilus* L. and *Hadena turbulenta* Hbn. produced 1369 *Compsilura*, all but 52 of which issued the year of their inception.

In 1933, 27 *Compsilura* adults were obtained between April 29 and May 5 by forced emergence in the laboratory. These flies were mated, and reproduction on *Nygmia phaeorrhoea* Don., *Stilpnotia salicis* L., *Malacosoma americana* Hbn., *Euphydryas phaeton* Dru., *Ascia rapae* L., and *Autographa brassicae* Riley followed. Other species found most favorable for reproduction but occurring later in the season were *Hamadryas antiopa* L., *Paonias myops* S. & A., *Platysamia cecropia* L., *Callosamia promethea* Dru., *Cingilia catenaria* Dur., *Datana ministra* Dru., *Danaus*

Table 1.—Emergence of progeny of pure and crossed stock of the second and third generations of *Compsilura concinnata* from various host species.

Parasitization Date	No. Host Larvae	Host Larval Instar	Generation of Parent Fly	No. Adults Emerging Same Season	No. Overwintering Larvae	Per Cent Overwintering Larvae
			Euchaetias egle			
Aug. 18–21	50	Intermediate	Second	14	2	12
Aug. 29	100	Penultimate	Third	92	6	6
			Hyphantria cunea			
Aug. 22–23	15	Last two	Second	5	8	61
Aug. 30	10	Last	Third	3	4	57
Aug. 29	25	Last two	Crossed	4	7	64
			Melalopha inclusa			
Aug. 3	60	Penultimate	Second	5	5	50
			Symmerista albifrons			
Sept. 14	10	Intermediate	Third	1	5	83
Sept. 23–25	12	Last	Crossed	1	2	66

menippe Hbn., *Sphinx gordius* Cram., *Hyphantria cunea* Dru., *Euchaetias egle* Dru., *Symmerista albifrons* S. & A., *Melalopha inclusa* Hbn. and *Paonias excaecata* S. & A. The last five species were the only overwintering hosts that produced *Compsilura* in 1934. During the season 3317 larvae were parasitized, and from them a total of 1601 *Compsilura* were bred, all but 162 issuing the year of their inception.

The propagation experiment was discontinued in 1934. All the overwintering material was brought into the laboratory during the first week of April and 162 parasites issued between April 26 and May 9, 1934. As in the preceding year, the flies were mated and reproduction on about 2500 *Malacosoma americana* produced approximately 2000 puparia between May 20 and June 9.

Factors influencing hibernation of Compsilura.—It is thus seen that while *Compsilura* built up population at a rapid rate during the summer, comparatively few individuals overwintered. The reason for this is not entirely clear, although it appears to be dependent somewhat upon the host species. For example, the progeny of flies of the same generation developing concurrently in *Euchaetias egle* and *Hyphantria cunea* exhibit a difference in behavior apparently attributable to no other cause than host specificity. During August 1933 there was an aggregate parasitization of 758 *E. egle*, which produced 434 seasonal and 30 overwintering *Compsilura*, whereas in 406 *H. cunea* there were produced 147 seasonal

and 70 overwintering *Compsilura*. In other words, about five times as many overwintering flies were obtained from *H. cunea* as from *E. egle*. About the same ratio of emergence was maintained the previous year. Roubard (1922) has advanced an interesting explanation of hibernation in the case of certain muscids. According to him, it is due to an accumulation of excretory products, chiefly urates, which inhibit development until they can be eliminated. The principal reactivating influences are prolonged low temperatures and desiccation, although some species will respond to mechanical or physical stimuli.

During the course of the propagation experiment the flies belonging to the various generations were kept separated, in the belief that the adults of the latest generation would produce only overwintering prog-

Table 2.—Effect of stage of development of host when parasitized on emergence of progeny of late-generation *Compsilura* adults.

Parasitization Date	No. Host Larvae	Host Larval Instar	Generation of Parent Fly	No. Adults Emerging Same Season	No. Overwintering Larvae	Per Cent Overwintering Larvae
			Hyphantria cunea			
Aug. 14	75	Intermediate	Second	27	30	52
Aug. 22–23	15	Last two	Second	5	8	61
			Euchaetias egle			
Aug. 21	52	Intermediate	Third	22	1	4
Aug. 22	10	Last	Third	6	1	14

eny. This was not the case, however, as pure and crossed stock of second and third generations produced adults the same year as well as overwintering individuals. Some of the records in which this behavior is best shown are given in table 1.

It is true that a larger percentage of the progeny of the third generation overwintered than did those of the second generation, but this is believed to be due to a seasonal influence, since progeny produced late in the season more often hibernate than do those of earlier inception. If the percentage of overwintering progeny is computed at a time when adults of both generations are about equal in number, little difference will be found in their hibernation tendency.

Data concerning the fourth generation are too meager to be significant. An abundance of adults was obtained, but so few host species were available at this season of the year (October) that most of the flies died without issue. The only record of reproduction from this generation concerns a female mated September 25 and used on October 11 to parasitize a last-instar larva of *Symmerista albifrons*. In this instance the progeny hibernated and produced an adult the following spring.

The stage of development of the host larva when parasitized does not appear to influence hibernation. At least this is true in the case of the last three instars, for no attempt has been made to use very young larvae. In table 2 it is shown that both seasonal and hibernating forms were produced in caterpillars of *Hyphantria cunea* and *Euchaetias* regardless of their stage of development when parasitized.

As a rule late-season parasitization, irrespective of the host species, will produce more overwintering progeny than seasonal. Third-generation flies used to parasitize late-instar larvae of *Hyphantria cunea* and *Euchaetias egle* during the period August 30 to September 8 produced 110 seasonal and only seven overwintering progeny, whereas the same flies used from September 13 to 18 produced 29 overwintering and no seasonal progeny. Similar results were obtained by late-season parasitization of *Symmerista albifrons*. Data in connection with late-season parasitization are presented in table 3.

Table 3.—Effects of late-season parasitization on emergence of progeny of late-generation *Compsilura* adults.

Parasitization Date	No. Host Larvae*	Generation of Parent Fly	No. Adults Emerging same Season	No. Overwintering Larvae	Per Cent Overwintering Larvae
		Hyphantria cunea			
Aug. 30–31	45	Third	25	6	19
Sept. 13	25	Third	0	10	100
		Euchaetias egle			
Sept. 1–8	25	Third	6	1	14
Sept. 6	75	Third	79	0	0
Sept. 15	15	Third	0	10	100
Sept. 18	15	Third	0	9	100
		Symmerista albifrons			
Sept. 14–21	26	Third	1	10	90
Sept. 19–28	52	Crossed	1	13	92
Oct. 9–11	12	Fourth	0	1	100
		Paonias excaecata			
Sept. 22	2	Third	0	2	100
		Sphinx gordius			
Sept. 22	4	Third	1	0	0

* Host larvae in last two instars.

This seasonal influence may very well be the result of excretory accumulation, as suggested by Roubaud (1922), but in these studies no tests of urates were made to confirm his researches. His explanation of a chemical stimulus as a reactivating agent on a hibernating larva perhaps accounts for the seasonal emergence of *Compsilura* from those hosts destined to produce adults the year of their inception. There are many rearings on record in which *Compsilura* adults have been produced so late in the season that they perished for lack of hosts. This is particularly true in the case of emergence from *Ascia rapae* L. Parasitization of this species late in the fall invariably results in a large seasonal emergence with but few hibernating individuals. Since it appears that comparatively few *A. rapae* overwinter, it is probable that the only parasite larvae to hibernate are those infesting individuals destined to overwinter, while the others respond to a chemical stimulus caused by their host's development and emerge.

Practical application.—Early in June 1933 small shipments of *Compsilura* puparia were sent to the state of Washington for liberation in the area infested with the satin moth. At that time a good many of the host

species were in the intermediate instars and most susceptible to attack. This shipment was approximately two weeks or more in advance of any that could have been made from field-collected material, and consequently was more effective. Two other shipments September 6 and 11, totaling 600 puparia, were sent to Oregon for possible establishment as a parasite of the Pandora moth, *Coloradia pandora* Blake. It would be very difficult to obtain *Compsilura* at this season of the year by means other than laboratory propagation.

In 1934, 2034 puparia were obtained by propagation of forced adults and sent to the state of Washington for liberation as before. This material was shipped in four lots, on May 23 and 28 and June 2 and 6, and was released under satisfactory conditions. *Compsilura* puparia from field-collected larvae were not obtainable in appreciable numbers until the last week in June.

Summary.—*Compsilura concinnata* Meig. is one of the most important tachinid parasites imported into the United States. It is firmly established in New England, New York and eastern Pennsylvania, and southward to the northern half of New Jersey. Because of its effectiveness several attempts have been made to introduce it into other parts of the United States. The need of a means for supplying the parasite at the proper time led to its laboratory propagation.

Compsilura concinnata has three or four generations a year and passes the winter as an immature larva in various species of lepidopterous pupae. The progeny of the second and third generations may either issue or overwinter.

An attempt to propagate the species in the laboratory was attended by some success, but no means were devised whereby large numbers of flies could be obtained. Parasitization was accomplished by individual handling, which proved more dependable than any other method.

Reproduction is possible on a large number of common host species, and populations can be built up easily during the season. The difficulty of insuring an abundance of overwintering material for liberation purposes was overcome by forcing the emergence of the overwintering stock and propagating this under laboratory conditions.

The factors that influence the hibernation of *Compsilura* are unknown, although it is believed that the host species is important in this respect, particularly in midseason. A seasonal influence, irrespective of the species, appears to be exerted. The generation of the parent fly and the stage of the host when attacked seem to be of little importance.

The laboratory propagation of *Compsilura* made possible the shipment of puparia two to four weeks earlier in the spring and later in the summer than would be possible from field-collected material.—1-7-37.

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Seasonal Availability of Food Plants of Two Species of *Heliothis* in Eastern Georgia

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Within a radius of 50 miles of Savannah, Ga., occurrence of the active stages of the corn earworm, *Heliothis obsoleta* Fab., and of the tobacco budworm, *H. virescens* Fab., extends over a greater period than the growing season of their principal cultivated food plants. When the more favored cultivated food plants are wanting, the insects subsist on less favored cultivated plants or on wild food plants. *H. obsoleta* maintains itself principally on corn, but early in the spring and late in the fall it turns to wild food plants, and throughout the season the abundance and distribution of cultivated and wild plants that are less acceptable to it than corn are such that these plants are capable of supporting considerable populations of the larvae. *H. virescens* feeds principally on three species of wild plants, but it may subsist on many other wild hosts, and where tobacco is lacking it normally goes through the season on a succession of wild plants. Both species of *Heliothis* often occur in large numbers on the wild hosts, and the seasonal distribution of these plants is such that both insects may survive throughout the season without access to cultivated plants. In the following paragraphs is given the occurrence of the insects and of the plants they attack.

Seasonal history of the insects.—Studies of the seasonal history of *Heliothis obsoleta* and *H. virescens* were made from 1930 to 1934, inclusive. The seasonal occurrences of these insects are similar in extent but show important differences. Each species passes through a complete generation in approximately one month during summer, and in a month to six weeks in spring and fall.

Heliothis obsoleta.—Moths of the corn earworm usually begin to emerge from hibernation during the last week in March, although the exact time will vary with different years, and emergence continues until the last week in July. Individuals begin to rest as pupae in the soil during June and July, and often such individuals enter hibernation from these periods. By October 15 most of the individuals have entered hibernation. During all the period from the last week in March until the middle of October the insect is present in all stages in the field, and the generations overlap. Six generations in a year are possible.

Heliothis virescens.—Moths of the tobacco budworm begin to emerge from hibernation during the last week of March, and by the first week of May emergence is complete. By the first week of September individuals begin to hibernate as pupae in the soil, and by November 1 practically all individuals are in hibernation. Four to six generations annually seem to be characteristic of this insect in the area discussed, and the generations are often, or even usually, distinct and separated by periods in which larvae are not to be found.

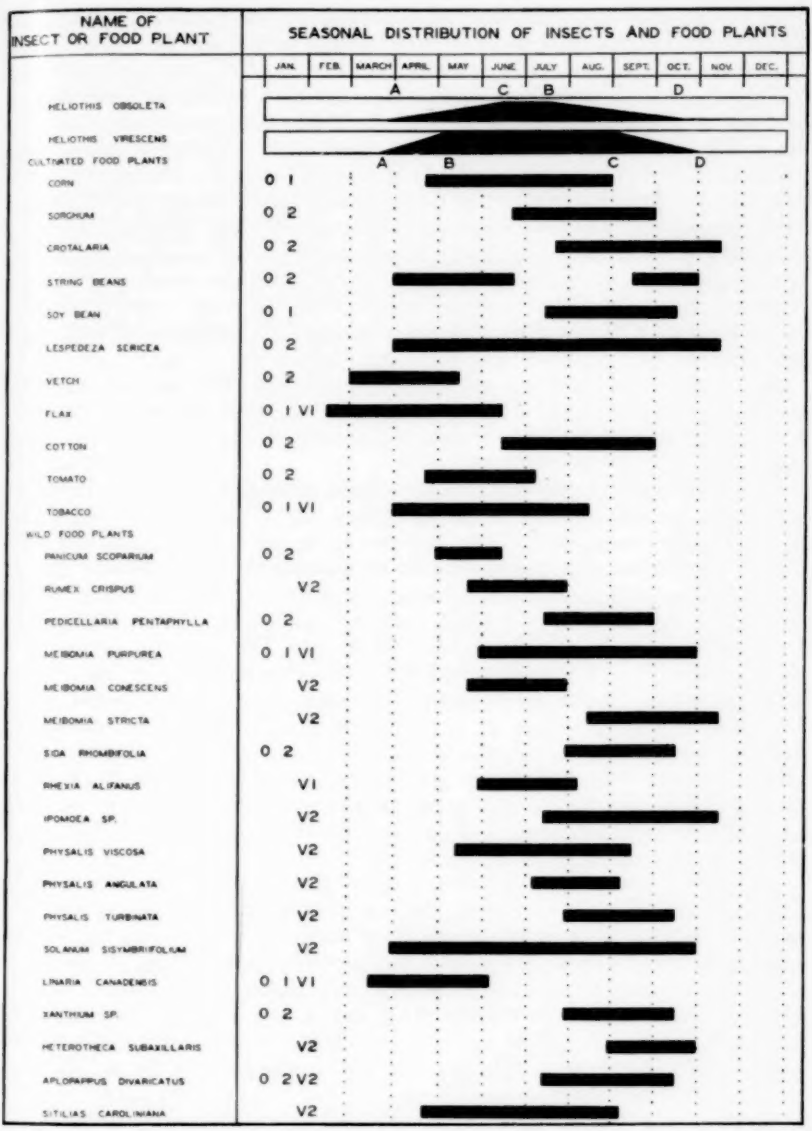

Fig. 1.—Seasonal occurrence of *Heliothis obsoleta* and *H. virescens* and their food plants in the coastal plain of southeastern Georgia. Shaded areas show occurrence of active stages of the insects and the periods when plants are suitable as food for larvae. Outlined areas show hibernation period. A, Moths begin to emerge; B, Emergence from hibernation complete; C, Individuals begin to hibernate; D, Complete hibernation begins. Plants arranged in botanical order. O, Plants attacked by *H. obsoleta*, 1 indicating principal food plants and 2, occasional food plants. V, 1 and 2 give similar information for *H. virescens*.

In the case of *Heliothis obsoleta*, emergence from hibernation occupies a relatively long period, as does entry into hibernation, and hibernating pupae are always present in the soil. In the case of *H. virescens*, however, emergence from hibernation takes place during a relatively brief period, as does also entrance into hibernation. These differences are shown in fig. 1. For these reasons *H. virescens* is much more dependent upon a long seasonal distribution of food plants than is *H. obsoleta*, because from the first week in May to the first of September no individuals of *H. virescens* are hibernating. Thus *H. virescens* has no reserve population capable of surviving unfavorable conditions that may cause decimation of the active stages of the insect. As will be shown, *H. virescens* seems to meet this situation by a somewhat greater adaptability to wild food plants than is the case with *H. obsoleta*. But both species are shown to be quite general feeders.

At no time during the course of these studies did it appear that the population of larvae of either species were deprived of sufficient food. During all seasons much more food was available than the current larval populations could devour.

Seasonal availability of cultivated food plants.—In table 1 larvae of *Heliothis obsoleta* are recorded as attacking 11 species of cultivated plants, while those of *H. virescens* are recorded as attacking but two. Of the cultivated plants attacked by *H. obsoleta* but four are of sufficient importance to warrant discussion. Sorghum, *Crotalaria* spp., string beans, *Lespedeza sericea*, vetch, cotton and tomato are attacked infrequently in this area by larvae of *H. obsoleta*, and no instance of damage to any of these crops has come to light during five years, 1930–1934, inclusive. That none of these plants is extensively infested is probably due to the presence of more favored food plants in abundance throughout the season. It is possible that in localities where these cultivated plants are usually damaged by larvae of *Heliothis* spp., the said more favored plants do not occur in sufficient abundance to feed the populations of these insects, especially during periods when corn is unsuitable as larval food for *H. obsoleta*.

Corn.—In the area discussed, corn is planted from the last week in February to the last of May. *Heliothis obsoleta* larvae begin to occur upon it during May, when both the "bud" and unfolding tassels are attacked. During June, July and August, corn is available in condition suitable for larval food, and in these months almost the whole population of *H. obsoleta* is found on corn. No plant in this area seems capable of competing with corn in attractiveness to this species. On the other hand, not a single specimen of *H. virescens* was found on corn during the five-year period mentioned.

Soybean.—This is becoming one of the principal food plants of *Heliothis obsoleta* larvae in the area discussed. As leaf feeders, the larvae are found on this plant from the time when it bears only a few leaves until it is through blooming. Plants most suitable as larval food occur in the greatest acreage during August, September and the first half of October, when the populations of *H. obsoleta* larvae are usually largest and sometimes occasion severe injury. This is more especially the case

Table 1.—Plants accepted as foods by the larvae of *Heliothis* spp.

HELIOTHIS OBSOLETA

Cultivated Plants

	Parts of Plants Eaten
Principal food plants	
Corn, *Zea mays* L.	Buds, tassels, ears.
Soybean, *Soja max* (L.) Piper.	Leaves, buds, young pods.
Flax, *Linum usitatissimum* L.	Green bolls, tender leaves, buds.
Tobacco, *Nicotiana tabacum* L.	Unripe bolls.
Occasional food plants	
Sorghum, *Sorghum vulgare* Pers.	Unripe seed head.
Crotalaria spp.	Leaves.
String beans, *Phaseolus vulgaris* L.	Green pods.
Lespedeza sericea (Thunb.) Benth.	Leaves.
Vetch, *Vicia sativa* L.	Leaves.
Cotton, *Gossypium herbaceum* L.	Squares, terminal buds, green bolls.
Tomato, *Lycopersicon esculentum* Mill.	Unripe fruits.

Wild Plants

Principal food plants	
Meibomia purpurea (Mill.) Vail.	Unripe seeds.
Linaria canadensis (L.) Dum.	Green bolls.
Occasional food plants	
Panicum scoparium Lam.	Green seed head.
Pedicellaria pentaphylla (L.) Schrank.	Green seed pods.
Sida rhombifolia L.	Green bolls.
Xanthium sp.	Green seed, burs, buds.
Aplopappus divaricatus (Nutt.) A. Gray.	Flower buds, unripe seed pods.

HELIOTHIS VIRESCENS

Cultivated Plants

	Parts of Plants Eaten
Flax, *Linum usitatissimum* L.	Green bolls, tender leaves, buds.
Tobacco, *Nicotiana tabacum* L.	Young leaves, buds.

Wild Plants

Principal food plants	
Meibomia purpurea (Mill.) Vail.	Unripe seeds, buds, tender leaves.
Rhexia alifanus Walt.	Unripe seed bolls, flower buds.
Linaria canadensis (L.) Dum.	Green bolls.
Occasional food plants	
Rumex crispus L.	Unripe seeds.
Meibomia canescens (L.) Kuntze.	Unripe seeds.
Meibomia stricta (Pursh) Kuntze.	Unripe seeds.
Ipomoea sp.	Unripe seeds.
Physalis viscosa L.	Unripe fruit.
Physalis angulata L.	Unripe fruit.
Physalis turbinata Medic.	Unripe fruit.
Solanum sisymbriifolium Lam.	Leaves, unripe fruit.
Heterotheca subaxillaris (Lam.) Britton & Rusby	Unripe seed pods, buds.
Aplopappus divaricatus (Nutt.) A. Gray	Flower buds, unripe seed pods.
Sitilias caroliniana (Walt.) Raf.	Unripe seed pods.

in sections where *Meibomia purpurea* is less plentiful, while in the vicinity of heavy stands of *M. purpurea* the soybeans are less frequently attacked by *H. obsoleta* larvae, the seeds of *M. purpurae* apparently being

preferred to the soybeans. Observations seem to show that the moths of *H. obsoleta* congregate in soybean fields to feed on the blossoms. They then hide in the fields during the day and apparently lay their eggs rather incidentally.

FLAX.—This plant first became available in 1934, when about 500 acres were planted in the vicinity of Estill, S. C. Planted principally in February, the plants bore green bolls during April and May, and in some cases were infested and injured by larvae of *Heliothis obsoleta* and *H. virescens*. Larvae of the first species were several times more plentiful than larvae of the second, and both passed through a generation in April and one in May, following which the moths of *H. obsoleta* apparently migrated to corn, while the moths of *H. virescens* migrated to *Rhexia alifanus*. The flax occupied a position entirely similar to that of *Linaria canadensis* in that it provided food for larvae of each species at a season when alternative foods were scarce. Yet *L. canadensis* seemed to be preferred to flax, since in the vicinity of large stands of this plant the flax was little infested, while at a distance from *L. canadensis* in large stands, flax was severely injured. When feeding on flax, larvae of both species feed principally on the green bolls, but in flax too young to bear bolls the buds and tender leaves were devoured. The flax fields were attractive to moths while in blossom, and it appeared that, as was the case with soybeans, moths concentrated in these fields to feed, rested there during daylight, and deposited their eggs upon the plant.

TOBACCO.—Throughout most of the area under discussion, tobacco is not grown except on the western border, about 35 miles west of Savannah, Ga., where it is attacked by both species of *Heliothis*, *H. virescens* larvae attacking the tender leaves and buds while larvae of *H. obsoleta* attack the seed capsules. In most of the area, *H. virescens* occurs throughout the season on wild plants in at least as great abundance as in the tobacco-growing sections, and it is clear that the insect is in no wise dependent on tobacco to maintain important populations.

Seasonal availability of wild food plants.—Of wild food plants attacked by larvae of *Heliothis obsoleta* and *H. virescens*, two are usually attacked by the former and three by the latter, although 15 species are occasionally or often attacked. The more important of these wild food plants are those discussed in the following paragraphs. Their availability during the year in suitable stages as larval food is shown graphically in fig. 1.

Meibomia purpurea.—This is a common wild, and sometimes cultivated, forage plant in the area under consideration. It is the principal food plant of the larvae of both *Heliothis obsoleta* and *H. virescens*, beginning with August. It is very abundant in cornfields and along roadsides in sandy or sandy loam soil, often occurring in pure stands 3 to 5 feet high. In cornfields, whether originally planted or self-sown, it springs up after the last cultivation and reaches maturity after the ripening of the corn. In such cases, it serves as a cover crop and provides hay, which is often cut at the time corn is harvested. In fallow lands or along roadsides this plant begins to bloom and mature seeds by June 1. From then on throughout the season it becomes increasingly plentiful until it

reaches its greatest abundance during September and October. By the first of November most of the seeds are ripe and too hard for larvae to eat. During August, September and October it occurs in great profusion, the seeds are borne in large numbers, and a cornfield bearing a pure stand of this plant offers food for very many more larvae of *H. obsoleta* than does the corn. Larvae of *H. virescens* begin feeding on the leaves, buds and unripe seeds in July, their numbers increasing from then on. Three successive generations have been recognized. One principal generation of *H. obsoleta* occurs on this plant during September, by the time corn suitable for larval food has disappeared from the field. Usually several times as many larvae of *H. virescens* as of *H. obsoleta* are found on this plant, even during September, when the latter are most plentiful. Other than *Linaria canadensis*, *Meibomia purpurea* is the most important wild food plant of the larvae of both *H. obsoleta* and *H. virescens* during the season. When cut as hay, this plant produces a new head bearing blooms and seeds, and through this habit provides unusually late food for the latest occurring larvae of both species of *Heliothis*.

Meibomia canescens.—This species is much less abundant than *M. purpurea* and develops somewhat earlier in the season. Larvae of *H. virescens* feed upon the unripe seeds before the preferred *M. purpurea* is available. The plant inhabits sandy, uncultivated soil along roadsides or waste places, never occurring in pure stands but as small groups of plants or as single individuals.

Meibomia stricta.—This plant is an inhabitant of sandy ridges, especially cut-over lands covered with small oaks. It is a late-maturing species and is among the latest available foods of larvae of *H. virescens*, bearing unripe seeds until mid-November. In its environment it is abundant, although the plants are scattered among a varied vegetation, and it does not occur in the pure stands characteristic of *M. purpurea*.

Rhexia alifanus.—During June, July and the first week of August this pink-flowered plant occurs in incredible abundance in "flatwoods," or moist pine lands. The soil is usually acid, often clay, and the principal associated plant is *Pinus taeda* L., the loblolly, short-leaf, or old field pine. From the middle of June to the middle of July the plant blooms most profusely and often it appears as a pure stand. In the right environment one may often drive along a highway for miles and observe the flatwoods covered with *Rhexia alifanus* on each side as far as one can see. During this time the plant provides food for a large population of *H. virescens* larvae, which devour the flower buds and unripe bolls. In 1934 a single generation occurred, during June, on this plant, few larvae being found at other times. General observations indicate that this plant serves to tide over *H. virescens* from its most common spring food, *Linaria canadensis*, to its most important fall food, *Meibomia purpurea*. *R. alianus* was most abundant after *Linaria* had disappeared and before *M. purpurea* had become abundantly available, and a large proportion of the larvae of *H. virescens* of the June, or probably third, generation accepted this plant as food. Neither *L. canadensis* nor *M. purpurea* grows in the same locations as *R. alifanus*. Before and after the generation of *H. virescens* larvae that occurred on *R. alifanus* in June no infestation

of *H. virescens* was found on other plants in the moist pine lands. It seemed probable, therefore, that late in May or in June the moths of *H. virescens* migrated to *R. alifanus* to lay their eggs, and the resulting moths migrated out of the moist pine lands upon emerging during July, to seek food in other environments.

Linaria canadensis.—This is an early-season plant which blooms and matures seed from the last of March to the last of May. By the first part of June the plants have ripened and disappeared for the season. *Linaria canadensis* is very important in providing food for the earliest-occurring larvae of both *Heliothis obsoleta* and *H. virescens*, and one or two generations of both species occur upon it. From this plant *H. obsoleta* usually goes to corn during June, while *H. virescens* goes principally to *Rhexia alifanus*. *L. canadensis* is found on sandy or sandy loam fallow lands during the first season that these lie idle, or on lands plowed early in the season and thereafter abandoned. Appearing early, before many other plants occur to compete with it, *L. canadensis* often is found in pure stands, acres in extent, thus providing a tremendous amount of food for the larvae of these insects. The seeds apparently remain viable in the soil for years. Since the plant appears not to tolerate much competition it is seldom seen except under the conditions described, although occasional plants occur along roadsides, in waste places, and sometimes in lawns. While this plant is available most of the larvae of these insects present in the field occur on it.

Physalis angulata.—This is an important food plant of larvae of *Heliothis virescens*. The plant inhabits moist spots of soils having high humus content. In cultivated ground a single plant develops hundreds of lanternlike seed pods, each enclosing a small tomatolike fruit. It is these fruits that are eaten by the larvae, and often nearly all the fruits borne by a plant are devoured. More than a single fruit is required by a larva to reach full growth, hence it crawls from fruit to fruit. In grass and weed areas, where the plant encounters competition from other species of plants, it grows less luxuriantly, but is similarly attacked. This is one of the most important of the late-summer food plants of *H. virescens*, and except for *Meibomia purpurea*, the insect seems to prefer it to most other plants then available.

Physalis viscosa.—This plant is sometimes very plentiful along roadsides through salt marshes. The fruits are usually devoured by larvae of *Heliothis virescens* during July and August.

Physalis turbinata.—Ordinarily this species is found in heavier soils along fence rows of pastures or cultivated ground. It seems to be less common than *P. angulata* and *P. viscosa*, but is similarly attacked by larvae of *Heliothis virescens* during August and September.

None of the species of *Physalis* mentioned occur in such great abundance as several other food plants of *H. virescens* larvae, and although these larvae accept the *Physalis* fruits as readily as they do *Meibomia* spp., the limited abundance of the former provides food for only a small percentage of the larvae of *H. virescens* present during the summer and early in the fall.

Solanum sisymbriifolium.—This species is especially interesting as a

food plant of *Heliothis virescens* because of its long period of availability. It is grown as an ornamental because of its bright red fruit, but has escaped to roadsides and waste places, where it occurs sparingly. The larvae attack it during the entire period that they occur in the field, devouring both the tender leaves and the fruit.

Aplopappus divaricatus.—From August to October this plant is very abundant, principally in lands recently cultivated, where it occurs in pure stands, acres in extent. It occurs also in waste places and along roadsides in less abundance. Thus it occupies a position in fall similar to that held by *Linaria canadensis* in spring. Larvae of *Heliothis virescens* feed on the flower buds and unripe seed pods, and while they are not found

Table 2.—Sequence of attacks on plants made by *Heliothis* spp.

APRIL-MAY	JUNE-JULY-AUGUST	SEPTEMBER-OCTOBER
HELIOTHIS OBSOLETA		
One or two generations on *Linaria canadensis*, or on flax where available and when *L. canadensis* is absent.	Three generations on corn.	One or sometimes two generations on *Meibomia purpurea* or on soybeans when available and when *Meibomia* is absent.
HELIOTHIS VIRESCENS		
One or two generations on *Linaria canadensis*, or on flax where available and when *L. canadensis* is absent.	JUNE-JULY One generation on *Rhexia alifanus.*	JULY-AUGUST-SEPTEMBER-OCTOBER Two or three generations on *Meibomia purpurea.*

in particularly large numbers as compared with the populations of larvae found on *Meibomia purpurea*, the abundance of the plant on recently cultivated lands serves as a reservoir of food, available in places and at times when the more favored foods are scarce or wanting.

Usual occurrence on food plants.—Although both *Heliothis obsoleta* and *H. virescens* are general feeders, as has been indicated, a large percentage of the larval population of each species attacks certain plants in sequence during the year. These plant sequences are shown in table 2.

During a given year, a larger proportion of *Heliothis virescens* larvae were found on food plants other than those mentioned above than was the case with *H. obsoleta*. However, this may be due to the plentiful supply of corn present during the three summer months, to which the population of *H. obsoleta* is in large part attracted. General observations during several years show that *H. virescens*, even when feeding on no cultivated crop, is fully is abundant throughout a given season as is *H. obsoleta* in the area studied. This is probably due to the abundance of its three principal wild food plants.

The general distribution of *Heliothis virescens* is much greater than that of *H. obsoleta* in the area studied. The principal food plants of the latter occur on cultivated ground, and a large percentage of the population of the insect is confined to cultivated areas throughout the year.

On the other hand, *H. virescens* occurs in most types of plant association except the swamp lands. Large infestations on *Rhexia alifanus* in the flatwoods and on *Meibomia stricta* on the sandy ridges occur miles distant from any cultivated fields, while *Heliothis virescens* is equally as abundant as *H. obsoleta* in cultivated areas when attacking *Linaria canadensis* and *Meibomia purpurea*.

Summary.—An account is given of both the cultivated and the wild food plants of *Heliothis obsoleta* and *H. virescens* in the southeastern coastal plain within a radius of 50 miles of Savannah, Ga.

Larvae of *Heliothis obsoleta* were found to feed on 11 cultivated plants and seven wild plants. Larvae of *Heliothis virescens* attacked two cultivated plants and 14 wild plants.

Both species begin feeding on *Linaria canadensis* in April and May and conclude a season's feeding by attacking *Meibomia purpurea* in August, September and October.

During the summer months *Heliothis virescens* passes through one generation on *Rhexia alifanus*, and *H. obsoleta* passes through three generations on corn.

Where available, flax may replace *Linaria canadensis* as food for both species, in April and May. Where *Meibomia purpurea* does not occur in abundance, soybeans may serve as a principal fall host for larvae of *Heliothis obsoleta*.

The plants attacked by *Heliothis obsoleta* grow principally on tillable land, and a large percentage of the yearly population of this insect is concentrated in such lands.

Heliothis virescens attacks plants in many different environments, and is much more generally distributed than is *H. obsoleta*.

Tobacco is grown only on the western outskirts of the area, and elsewhere *Heliothis virescens* maintains itself in large populations almost wholly on wild plants. Its yearly population seems to be fully equal to that of *H. obsoleta*. This may be explained in that the uncultivated lands upon which the wild food plants of *H. virescens* grow exceed the cultivated lands which produce the principal foods of *H. obsoleta* in this area.

At no time during any year of the period 1930 to 1934, inclusive, was either species deprived of sufficient food. The larvae devoured only a small percentage of the available food of any of the plants, which might readily have accommodated several times the larval population that actually occurred.—8-12-36.

Contact Insecticidal Properties of Various Derivatives of Cyclohexylamine

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The physiological action of organic amines upon the higher animals has been the subject of a tremendous amount of research. The early work

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of Brown & Fraser in 1869, and more recently that of Burn & Dale (1915), and the numerous accounts published by Renshaw, the latest of which is Renshaw & McGreal (1932), have attributed high toxicity and paralytic action to many organic amines.

Tattersfield & Gimingham in 1927 published the first work detailed enough to be spoken of as the beginning of an exploratory survey of the insecticidal properties of the amines. Since that time numerous in-

Classification of Cyclohexylamine Derivatives Tested

I. N-alkyl derivatives
- N-methyl
- N-ethyl
- N-n-propyl
- N-isopropyl
- N-allyl
- N-n-butyl
- N-isobutyl
- N-amyl
- N-octyl*

II. N-alkyl-acyl derivatives
- N, N-methyl-acetyl
- N, N-ethyl-acetyl
- N, N-n-propyl-acetyl
- N, N-n-butyl-formyl
- N, N-n-butyl-acetyl
- N, N-amyl-formyl
- N, N-amyl-acetyl
- N, N-amyl-propionyl
- N, N-amyl-butyryl
- N, N-amyl-benzoyl
- N, N-octyl-acetyl

III. N-acyl derivatives
- N-formyl
- N-acetyl
- N-benzoyl

IV. N-aryl or aralkyl derivatives
- N-phenyl
- N-benzyl
- N-benzyl dicyclohexylamine

V. N, N-aryl or aralkyl-acyl derivatives
- N, N-phenyl-acetyl
- N, N-benzyl-acetyl

VI. Miscellaneous N or N, N-substituted derivatives
- N-dinitrophenyl
- N-p-nitrobenzyl-o-methyl
- N, N-nitroso-benzyl
- N-nitroso-dicyclohexylamine
- N-tetrahydrofurfuryl
- N, N-tetrahydrofurfuryl-acetyl
- Cyclohexylisothiocyanate
- Dicyclohexyl thiourea
- N-benzyl-o-methyl
- N-p-chlorbenzyl-o-methyl
- N, N-benzyl-acetyl-o-methyl

* Prepared from 2-ethyl hexanol.

vestigators have explored the field or organic chemicals in search of compounds which might be useful as insecticides. During the course of these investigations a great variety of organic amines were tested. However, as far as the amines as a class are concerned, very little information was obtained regarding the relationship of physical properties and molecular structure to toxicity. This may be because in most of the investigations the selection of compounds was restricted by commercial availability, which in turn limited the number of closely related compounds tested, or, on the other hand, may be caused only by the highly empirical nature of insect toxicology.

Cyclohexylamine was chosen as the parent compound in this investigation because it was relatively inexpensive and possessed toxicity which was apparently greater than that of any of the primary amines recorded in the literature.

Methods.—The various compounds listed have been tested in the laboratory on the aphid *Myzus porosus* Sand., and the greenhouse red spider, *Tetranychus telarius* (Linné).

The aphid tests were conducted in the same manner and in an apparatus similar to that described by Tattersfield & Morris (1924). Twenty mature aphids were removed from a rose plant by means of a camel's hair brush and were placed in a petri dish having a flannel disk in the bottom to prevent the insects from crawling away before the spray was applied. Five to seven replicates of such individual tests were employed for each dilution of a given toxicant. The datum points in the accompanying diagrams represent the mean percentage mortality obtained in five to seven replicate tests made at a particular dilution.

An accurate method for conducting red spider tests was not available, and the writer could not improvise any more satisfactory method than

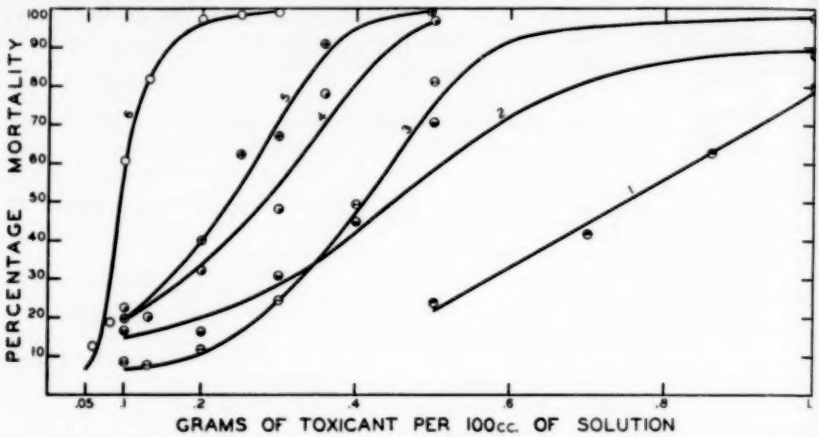

Fig. 1.—Comparative toxicity of certain N–alkyl derivatives of cyclohexylamine upon *Myzus porosus*. Curve 1, cyclohexylamine; curve 2, N–methyl cyclohexylamine; curve 3, N–propyl cyclohexylamine; curve 4, N–n–butyl cyclohexylamine; curve 5, N–amyl cyclohexylamine; curve 6, N–octyl cyclohexylamine.

spraying infested plants. However, particular care was taken in the selection of material to obtain plants with a similar degree of infestation and with the greater number of mites in the mature stage. This method did not by any means eliminate the extreme variations attendant upon the use of the red spider as a test animal. By counting the dead and live spiders on all leaves and parts of treated plants, and by replicating each dilution at least five times, it was found that a fairly accurate evaluation could be made and represented in the form of a curve for the various toxicants employed.

Cyclohexylamine itself was the only compound tested which was soluble in water, so that all of its various derivatives had to be dissolved first in other solvents and then solubilized, or solubilized directly by the addition of sulfonated oils or soaps. The physical properties as well as the chemical properties of the different compounds varied greatly and necessitated the use of different solubilizers in varying proportions to obtain even a fairly comparable uniformity in the diluted sprays. All N, N–alkyl–acyl derivatives of cyclohexylamine could be solubilized by

use of a commercial sulfonated castor oil (*Nopco 1597*) at amounts varying from 10 to 30 per cent by volume of the compounds in this class. The resulting mixtures when diluted with water for use in spraying possessed only a slight Tyndall effect when viewed through a glass cylinder exposed to light. The N–alkyl derivatives of cyclohexylamine were similarly solubilized by use of soluble potassium fish-oil soap or a coconut-oil soap (*Pango*) in amounts varying from 15 to 25 per cent by volume of the toxicant.

In the aphid tests diphenyl butyl sodium sulfate (*Aresket*) was employed as the wetting agent at a concentration of .05 per cent by weight

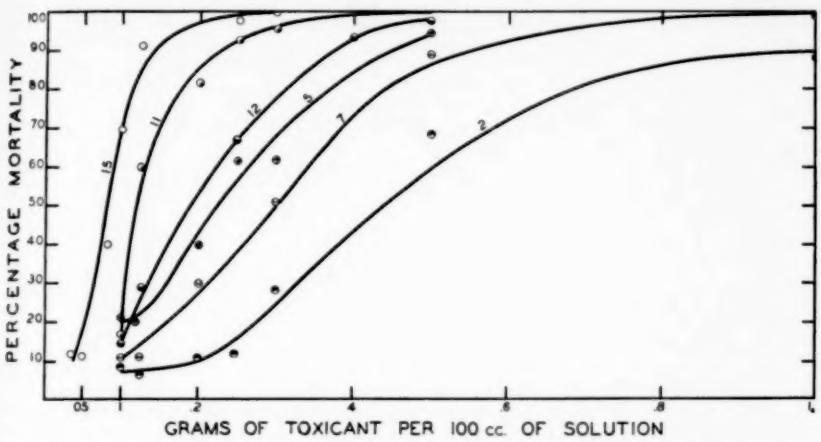

Fig. 2.—Toxicological effects of N–acylation of certain N–alkyl derivatives of cyclohexylamine upon *Myzus porosus*. Curve 2, N–methyl cyclohexylamine; curve 5, N–amyl cyclohexylamine; curve 7, N, N–methyl–acetyl cyclohexylamine; curve 11, N, N–amyl–acetyl cyclohexylamine; curve 12, N, N–amyl–formyl cyclohexylamine; curve 15, N, N–amyl–benzoyl cyclohexylamine.

of the spray volume. The same wetting agent was employed in the red spider tests at a concentration of .1 per cent.

Check tests of water plus the wetting agent and solubilizer were made with every series of tests conducted for each compound. In no case did any appreciable kill result and therefore no allowances were made in computing mortality percentages.

Toxicity of N–alkyl derivatives to *M. porosus*.—In fig. 1 toxicity curves for cyclohexylamine (curve 1) and certain of its N–alkyl derivatives (curves 2–6) are represented. It will be noted that N–alkylation of cyclohexylamine tends to increase the toxicity of the parent compound. It may be said, in general, that toxicity increases progressively as the number of carbon atoms in the alkyl group is increased from methyl to octyl. This is not strictly true for it is not possible to determine significant differences in the toxicity of N–methyl and N–ethyl cyclohexylamine.

The split chain N–alkyl derivatives, isopropyl and isobutyl, were more toxic than the parent compound, but did not in any case produce results significantly different from their corresponding N–n–alkyl derivatives.

N-allyl cyclohexylamine was more toxic than its corresponding saturated form of N–n–propyl cyclohexylamine (curve 3), and closely approximated the toxicity of N–n–butyl cyclohexylamine (curve 4). N–iso–butenyl cyclohexylamine could not be distinguished from N–n–butyl cyclohexylamine. These results would indicate that unsaturation in the alkyl group produces only minor variations in toxicity from the corresponding saturated alkyl derivative.

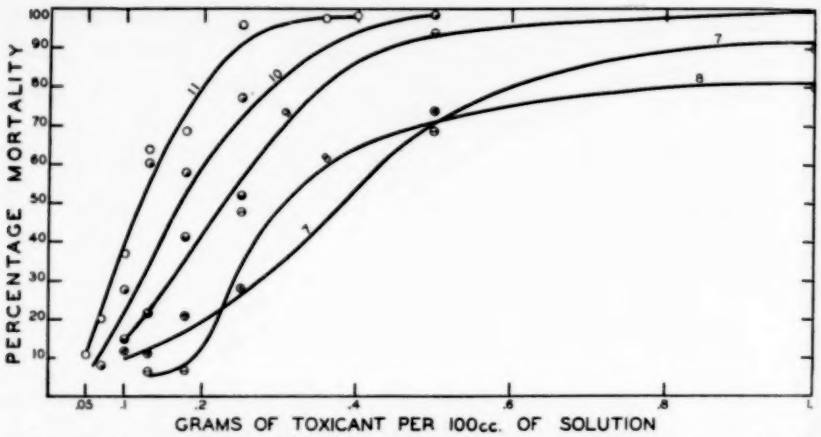

Fig. 3.—Comparative toxicity of certain N, N–alkyl–acetyl derivatives of cyclohexylamine upon *Tetranychus telarius*. Curve 7, N, N–methyl–acetyl cyclohexylamine; curve 8, N, N–ethyl–acetyl cyclohexylamine; curve 9, N, N–n–propyl–acetyl cyclohexylamine; curve 10, N, N–n–butyl–acetyl cyclohexylamine; curve 11, N, N–amyl–acetyl cyclohexylamine.

The most toxic N–alkyl derivative tested was octyl (curve 6) which was found to be approximately 7.5 times as toxic as the parent compound (curve 1) when compared at concentrations required to produce a 50 per cent mortality.

Toxicity of N–alkyl–acyl derivatives to *M. porosus*.—The previously tested series of N–n–alkyl derivatives were N–acetylated and tested again. It was found in each case that N–acetylation increased the toxicity corresponding to that represented by a comparison of the toxicity curves, fig. 2, of N–methyl cyclohexylamine (curve 2) and N, N–methyl–acetyl cyclohexylamine (curve 7). N, N–octyl–acetyl cyclohexylamine was, as might be expected, the most toxic N, N–alkyl–acetyl derivative tested. However, the octyl derivative proved to have certain disadvantages from the manufacturing point of view, so that the next most toxic N–alkyl derivative, namely N–amyl cyclohexylamine, was selected to determine the effect of substituting other acyl groups.

N, N–amyl–formyl cyclohexylamine (curve 12) was found to possess

only slightly more toxicity than N–amyl cyclohexylamine (curve 5). The N–benzoyl derivative (curve 15) on the other hand was almost twice as toxic as N–acetyl derivative (curve 11), approximately three times as toxic as N–amyl cyclohexylamine and approximately 10 times as toxic as cyclohexylamine itself.

Red spider tests.—During this investigation some of the compounds which appeared particularly toxic to aphids were tested on a wide variety of soft-bodied insects. Certain compounds proved to be quite specific in their action, and their toxicities as represented in the aphid tests could not be approached when applied to mites, thrips and mealybugs. The

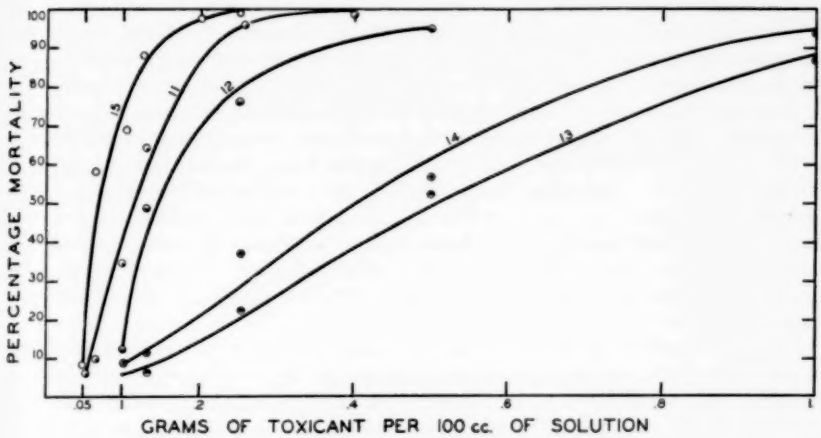

Fig. 4.—Comparative toxicity of N–acyl derivatives of N–amyl cyclohexylamine upon *Tetranychus telarius*. Curve 11, N, N–amyl–acetyl cyclohexylamine; curve 12, N, N–amyl–formyl cyclohexylamine; curve 13, N, N–amyl–propionyl cyclohexylamine; curve 14, N, N–amyl–butyryl cyclohexylamine; curve 15, N, N–amyl–benzoyl cyclohexylamine.

N–alkyl derivatives as a class, with the exception of N–octyl cyclohexylamine, were of this type. With this single exception, all the N–alkyl derivatives were found to be quite nontoxic to the greenhouse red spider. However, the N, N–alkyl–acyl derivatives showed exceptional toxicity to red spiders, and in certain instances they appeared to have greater toxicity than indicated by the aphid tests.

Toxicity of certain N, N–alkyl–acetyl derivatives of cyclohexylamine to *T. telarius*.—The same series of N–alkyl–acetyl derivatives of cyclohexylamine which were tested upon aphids were included in the red spider tests and the results obtained are represented by the toxicity curves presented in fig. 3.

The same relationship of toxicity to then umber of carbon atoms in the alkyl group, as demonstrated in the aphid tests, is shown to hold true in the case of the red spider. The N, N–methyl–acetyl (curve 7), and N, N–ethyl–acetyl cyclohexylamine (curve 8) are probably of the same

order of toxicity, as indicated by a double crossing of the two curves. With that single exception, toxicity increases progressively in significant degrees with each increase in the number of carbon atoms in the alkyl group from ethyl to octyl.

Comparative toxicity of N–acyl derivatives of N–amyl–cyclohexylamine to *T. telarius*.—Toxicity curves for five different N–acyl derivatives of N–amyl cyclohexylamine are presented in fig. 4.

There appears to be no toxicological relationship between the number of carbon atoms in the acyl chains such as was demonstrated for the alkyl group. The formyl derivative (curve 12) was less toxic than the acetyl (curve 11), but both were much more toxic than the propionyl (curve 13). The butyryl derivative (curve 14) was significantly more toxic than the propionyl but was still less toxic than the formyl derivative. N, N–amyl–benzoyl cyclohexylamine (curve 15) was the most toxic acyl derivative tested, and when the well-known insecticidal resistance possessed by the greenhouse red spider is taken into consideration, it may be justly said that this particular compound does possess exceptional toxicity.

Toxic properties of various other classes of cyclohexylamine derivatives.—Thus far only the N–alkyl and N, N–alkyl–acyl derivatives of cyclohexylamine have been discussed. The various other classes of derivatives previously listed have been tested on both *Myzus porosus* and the greenhouse red spider but none of the compounds were found to possess toxicity approaching that of the N, N–amyl–benzoyl cyclohexylamine.

The three N–acyl derivatives of cyclohexylamine were not particularly toxic, but formyl was slightly more toxic than acetyl, and acetyl, on the other hand, was considerably more toxic than benzoyl. This is just the reverse order of toxicity obtained when an alkyl group is substituted for the last N–hydrogen atom.

N–phenyl cyclohexylamine was slightly more toxic than N–benzyl cyclohexylamine. N–benzyl dicyclohexylamine was approximately as toxic as N–phenyl cyclohexylamine, showing that a slight increase in toxicity may be obtained by the introduction of two cyclohexyl groups into the molecule.

Both N–phenyl–acetyl and N–benzyl–acetyl cyclohexylamine were more toxic than corresponding compounds lacking the acyl group. It was apparent, however, that N–arylation or aralkylation would not increase the toxicity of an N–acyl derivative to such an extent as to be comparable in toxicity to an N–amyl–acyl derivative.

In the miscellaneous group of N or N, N–substituted derivatives, only, N, N–tetrahydrofurfuryl–acetyl and dinitrophenyl cyclohexylamine showed any appreciable toxicity.

Summary of the relationship of toxicity to molecular structure.—In this study ammonia (NH_3) was considered as a basic toxic radical which formed a nucleus for the synthesis of a highly toxic molecule. This was accomplished by substituting one or more organic nuclei for the ammonia hydrogen atoms.

It was found by a comparison of the results of Tattersfield & Gimingham (1927), and Richardson & Smith (1923), that the substitution of

one of the hydrogen atoms with a cyclohexyl group to form cyclohexylamine resulted in a primary amine which appeared to possess more toxicity than any of the primary aliphatic or aromatic amines tested by these writers. Cyclohexylamine is produced by the hydrogenation of aniline, and since it is much more toxic than aniline we may conclude that saturation of certain of the aromatic organic nuclei may give rise to a marked increase in toxicity. Richardson & Smith (1923) noted a similar instance in the case of pyridine and piperidine, the latter, being the hydrogenated form of the former, was found to possess about five times as much toxicity.

Various N–substitution derivatives of cyclohexylamine tested revealed that the substitution of second hydrogen atom of ammonia by an alkyl group tended to produce greater toxicity than various acyl, aryl or aralkyl substitutions. It was further shown that toxicity generally increased with each increase in the number of carbon atoms in the alkyl group at least up to and including octyl. The question then arises concerning whether this increase is due to a physiological action brought about by a change in chemical structure, or whether it is due to certain desirable physical properties imparted to the molecule by the long chain alkyl group. N–methylation of cyclohexylamine changes it from a water-soluble to an oil-soluble compound. Further increases in the length of the alkyl group render the compound progressively less soluble in water and more like an oil in physical properties. The penetrating qualities of petroleum oils are well known, and it may be that the introduction of a long alkyl group into the molecule increases its toxicity by the creation of similar physical properties, which in turn may greatly overbalance the loss in toxicity that might be expected to accompany a proportionate decrease in gram-molecular cyclohexylamine.

It was found that substitution of certain acyl groups for the third and last remaining hydrogen atom of ammonia produced a compound of exceptionally high toxicity providing that the other two replaceable hydrogen atoms were substituted by a cyclohexyl group and an alkyl group such as amyl. Benzoyl, acetyl, and formyl groups were found to increase toxicity when substituted on the nitrogen atom of a compound such as N–amyl cyclohexylamine, while N–propionyl and N–butyryl substitutions acted to decrease the toxicity of such a compound.

The high toxicity of the compounds N, N–amyl–benzoyl cyclohexylamine and N, N–amyl–acetyl cyclohexylamine demonstrate that all three hydrogen atoms of the ammonia radical may be substituted by certain organic nuclei to produce highly toxic compounds. There does, however, appear to be some specific relationship between these different substituted nuclei and toxicity which cannot be explained to any degree of satisfaction. This is illustrated by the fact that phenyl, benzyl or cyclohexyl groups substituted for the alkyl group greatly decrease toxicity. Likewise, substitution of the cyclohexyl group by a phenyl or alkyl group brings about a corresponding decrease in toxicity.

Summary.—Forty-one N– and N–N–substituted derivatives of cyclohexylamine were tested on the aphid *Myzus porosus* and the greenhouse red spider. The relationship of toxicity to molecular structure is discussed

in detail and the relative toxicity of various closely related derivatives is represented by toxicity curves.

Two compounds, namely N, N–amyl–benzoyl cyclohexylamine and N, N–amyl–acetyl cyclohexylamine were found to have exceptionally high contact insecticidal properties.

The writers are indebted to T. S. Carswell and H. L. Morril of the Monsanto Chemical Company, St. Louis, Mo., for preparation of the compounds tested and their splendid advice offered throughout the investigation.—1-8-37.

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Nicotine in Oil

A Promising Insecticide for Horticultural Purposes

P. O. Ritcher and R. K. Calfee, *Kentucky Agricultural Experiment Station, Lexington*[1]

History.—Use of atomized oils fortified with pyrethrum and other toxic agents as contact insecticides is a recent development in entomology. As early as 1903, Volck in California reported trying out the application of oil by the use of an air blast. However, it was not until 1933 with the work of various California entomologists (Cal. Ag. Exp. Sta., 1933; Herbert 1933, Parker 1933) and Ginsburg (1933) of New Jersey that the efficacy of oil-fog sprays for horticultural purposes was shown.

Up to the present, the main toxicant employed was pyrethrum. This material has been incorporated into highly refined petroleum base oil by steeping the ground pyrethrum flowers in the oil or by adding a concentrated pyrethrum extract to the oil through the use of intermediate solvents. Recently, rotenone incorporated in oil has been tested by a

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director. Early publication has been secured by payment of the printing charge.

number of workers and a patent for its incorporation was assigned to one of the pioneer companies in the development of household pyrethrum–oil sprays.

As early as 1929, R. H. Smith of California reported adding nicotine to spray oil in which he claimed it was only very slightly soluble. He found a few suitable intermediate solvents, among which was butyl alcohol. All his efforts to fix nicotine permanently in oil failed.

In 1933 Le Pelley reported attempting to extract the toxic principles of tobacco in oil but did not work out a satisfactory method of procedure. Also, in 1933, Herbert published an account of the use of *Vapona*, a light oil containing pyrethrum and nicotine for spraying with airplane equipment.

Smith, Meyer & Persing in 1934 used 95 per cent free nicotine, dissolved in kerosene, gasolene and petroleum ether, plus butyl alcohol as an intermediate solvent, as an atomized spray for the control of codling moth. They concluded that the material applied in that manner was impractical and turned their attention to a nicofumer which they used to vaporize atomized free nicotine or nicotine sulfate in a portable fumatorium by means of pressure and heat.

Table 1.—Comparative toxicity of oil–nicotine and aqueous nicotine sprays.

Material	No. Tests	No. Insects	Per Cent Kill
Check oil plus intermediate solvent	3	15	0
.63% free nicotine in oil	3	15	6.7
1.25% free nicotine in oil	3	15	40
2.5% free nicotine in oil	3	15	80
5% free nicotine in oil	8	40	100
2.5% free nicotine plus aqueous *Aresket*	3	15	0
5% free nicotine plus aqueous *Aresket*	3	15	0

Oil–nicotine as a horticultural spray was investigated in 1936 at the Kentucky Agricultural Experiment Station through a cooperative project between the Department of Entomology and Botany and the Department of Chemistry (Ritcher & Calfee 1936).

Preparation of oil–nicotine spray.—Ninety-five per cent free nicotine held in a completely volatile highly refined hydrocarbon distillate[2] by ethylene dichloride was used in the first tests. This mixture was homogeneous when first prepared but at the end of two days, in a 5 per cent solution, a number of brown droplets began to appear on the bottom of the flask. The droplets were composed principally of water and other impurities. One per cent and 2.5 per cent solutions of nicotine in the

[2] The highly refined hydrocarbon distillate used in these tests will be referred to hereafter as the base oil. Unless otherwise mentioned, it has the following specifications:

Specific gravity	.775–.785
Saybolt viscosity at 100° F	30 seconds
Flash point	170–180° F
Initial boiling point	370–390° F
Distillation end point	480–500° F
Unsulfonatable residue	Above 98%
Color	Water white
Odor	Practically none

Table 2.—Toxicity tests of nicotine and other insecticidal materials in refined hydrocarbon distillate.

Insect	Material	No. Tests	No. Alive	No. Dead
	Bell Jar–Settling Mist			
Nasturtium aphis	No treatment	2	26	0
	Oil check	1	29	7
	1% nicotine-oil	3	4	84
	.2% pyrethrum-oil	3	17	105
Pea aphis	No treatment	2	23	0
	Oil check	3	64	4
	1% nicotine-oil	6	35 (All paralyzed)	40
	.2% pyrethrum-oil	4	30 (All paralyzed)	35
	.2% rotenone-oil	1	0	11
Red spider	1% nicotine-oil	4	6	101
	2% pyrethrum-oil	4	7	95
Imported cabbage worms	Oil check	3	25	5
	1% nicotine-oil	7	56	14
	2% nicotine-oil	2	14	10
	.1% pyrethrum-oil	4	9 (7 paralyzed)	31
	.2% pyrethrum-oil	3	4	26
	Hand Atomizer			
Imported cabbage worms	1% nicotine-oil	3	8	22
	.05% pyrethrum-oil	3	1	29
Southern cabbage worms	No treatment	4	40	1
	Oil check	6	49	11
	1% nicotine-oil	6	16	45
	.05% pyrethrum-oil	6	23	37
	.1% pyrethrum-oil	6	13	47
Cabbage loopers	Oil check	4	21	19
	1% nicotine-oil	4	4	36
	.05% pyrethrum-oil	4	7	33
	.1% pyrethrum-oil	4	1	39
Cabbage loopers	Oil check	3	27	0
	1% nicotine-oil	3	16	13
	.1% pyrethrum-oil	3	6	18
Apple leaf hopper (nymphs)	Oil check	4	111	49
	.63% nicotine-oil	4	32	110
	1% nicotine-oil	4	6	195
Tingids	Oil check	2	21	38
	1% nicotine-oil	2	4	71
	.2% pyrethrum-oil	2	1	52
	.2% rotenone-oil	2	28	45
Mealy bug	2.5% nicotine-oil	1	0	73 adults 22 groups of young 49 egg masses
Potato beetles	1% nicotine-oil	5	16 (6 paralyzed)	8
Ham mites	No treatment	2	7	2
	Oil check	4	14	6
	1% nicotine-oil	12	41	97
	2% nicotine-oil	5	1	32
	3% nicotine-oil	2	0	21

base oil, using 95 per cent free nicotine and ethylene dichloride, remained stable for at least 10 days, and after that time water and other impurities began to settle out.

It was soon found that 100 per cent free nicotine was entirely soluble

in several light, highly refined oils without the use of an intermediate solvent. The resulting solution was clear and appeared to be permanent.

Commercial 95 and 50 per cent free nicotine can also be used in the preparation of an oil–nicotine spray. When a sample of commercial 95 per cent nicotine (by analysis 92.2 and 92.4 per cent) was shaken with sufficient oil to yield a 1 per cent solution, a slightly cloudy mixture was formed. This was centrifuged and the clear, water-white solution of nicotine in oil separated from the brown aqueous deposit. The oil-

Table 3.—Comparison of the effect on plants of oil–nicotine applied with an atomizer and with a semi-coarse continuous sprayer.

Plants Sprayed	Injury 24 Hrs. After Spraying	Injury 7 Days after Spraying	Injury 14 Days after Spraying
	Oil–Nicotine Applied as a Fine Fog		
Apple	None	None	None
Peach	None	None	None
Grape	None	None	None
Lettuce	None	None	None
Tomato	None	None	None
Bean	Very slight	Very slight	Very slight
Radish	None	None	None
Red Clover	None	None	None
Nasturtium	None	None	None
	Oil–Nicotine Applied with a Semi-coarse Continuous Sprayer		
Apple	None	Slight	Slight
Peach	None	Slight	Slight
Grape	Very slight	Some	Some
Lettuce	Some	Some	Some
Tomato	Some	Some	Some
Bean	Slight	Some	Some
Radish	Considerable	Much	Dead
Red Clover	Very slight	Slight	Some
Nasturtium	Some	Some	Dead

insoluble material was found by analysis to contain only .119 per cent of the total nicotine. The oil then, by difference, contained .9988 per cent nicotine.

The base oil also took up almost all the nicotine from a commercial 50 per cent free nicotine (49.5 per cent by analysis). The aqueous layer that separated after shaking contained 1.49 per cent of the total nicotine, giving a .985 per cent solution of nicotine in oil.

It appears from these results that the loss of nicotine in mixing small amounts of spray material is negligible when commercial 95 and 50 per cent free nicotine are used as sources of nicotine.

Toxicity of oil–nicotine to insects.—The first work with oil–nicotine, as mentioned above, was done with 95 per cent free nicotine held in base oil by means of ethylene dichloride. It was found that nicotine in oil is much more toxic to insects than are comparable aqueous nicotine solutions. This is undoubtedly true because of the penetrating action

of the oil and some additive toxic effect of the oil itself. A comparison of nicotine in oil and nicotine in water is given in table 1. The material was applied to adult green June beetles with a *Devilbiss* No. 16 atomizer.

Later, laboratory tests of oil–nicotine were made, using base oil to which 100 per cent free nicotine had been added directly. The results of these tests and of others made earlier when ethylene dichloride was used as an intermediate solvent for 95 per cent free nicotine are given in table 2. Oil–nicotine in certain tests was compared in toxicity with pyrethrum and rotenone in the same oil, all containing equal amounts of the same intermediate solvents. In some tests a modification of the apparatus described by Campbell & Sullivan (1934) was used. In others, use was made of a small, continuous hand atomizer designed by Ritcher and Calfee, thought to be unlike any now on the market.

In interpreting these results it should be remembered that only comparative toxicity between various materials is shown in the results of the bell jar–settling mist tests—not the complete effectiveness of any one material. The hand-sprayer tests more nearly approximate field conditions but here, too, an attempt was made to apply the materials in small enough amounts to give low kills in the oil checks.

It is of interest that nicotine in oil exhibited a spectacular knockdown that was much quicker than any other toxicant used.

It is concluded from a summary of the tests in table 2 and from field and greenhouse observations that nicotine in oil will give a high per cent kill of many insects. It also appears from comparative tests that 1 per cent free nicotine in oil has a toxicity in most cases equivalent to .1 per cent pyrethrum in oil. Double this amount of pyrethrum was used in many of the tests but this strength was probably unnecessary since various workers agree that pyrethrum reaches its maximum toxicity at about .1 per cent. One per cent free nicotine in oil is about the right concentration for field work.

Insects other than those shown in the tables, on which good kills were secured with nicotine in oil, include adult white flies, squash bug nymphs, adult blister beetles, thrips and stink bugs.

Effect on plants.—Ginsburg (1933, 1934, 1935) of New Jersey and others (Allen 1934) have shown that certain highly refined, volatile hydrocarbon distillates alone and stepped up with pyrethrum may be safely applied to plants if the spray is applied in the form of a fog. We have found that free nicotine in similar oils also may be safely applied to plants, provided use is made of proper equipment.

The plants to which nicotine in oil has been applied as a fog without causing appreciable injury are apple, peach, grape, elm, lettuce, tomato, bean, radish, cabbage, turnip, sweet potato, tobacco, red clover, morning glory, nasturtium, marigold, zinnia, snapdragon, cosmos, rose, geranium, arbor vitae and Scotch pine. Of these, lettuce, bean, sweet potato and clover are especially sensitive to overdose.

Since the oil used in these tests is highly refined and completely volatile, it is much safer on plants than less refined oils. Some hardy plants can be drenched with it with no resulting injury. According to Ginsburg (1934) chrysanthemums can be dipped in the oil. Comparison of the

effect on foliage of fog spraying and of spraying with a semi-coarse continuous sprayer is shown in table 3. In both cases, 2.5 per cent free nicotine in oil was applied to plants in the sun at a temperature of 91° F.

Two types of burn are noticeable when excessive nicotine in oil is applied to foliage. The more usual type is for dead spots and blotches to develop on the leaves wherever oil penetration occurred. This injury can be detected almost immediately after treatment. The second type of injury is an insidious one resulting from overdosing of hardier plants and is characterized by a loss of greenness and gradual yellowing of foliage. Such injury was found on drenched tobacco and lilies.

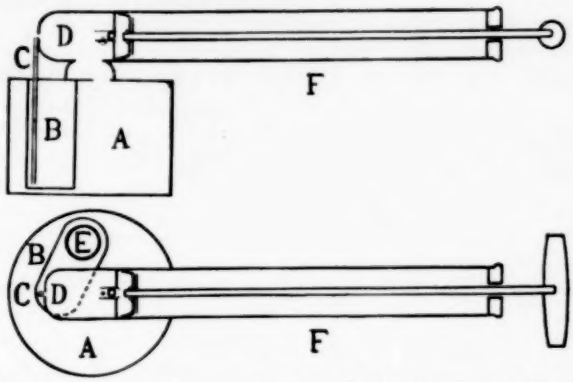

Fig. 1.—Details of new continuous atomizer. A, air chamber; B, liquid container; C, liquid delivery tube; D, air nozzle; E, filling cap; F, pump barrel.

Effect on animals.—It is well known that nicotine is very toxic to warm-blooded animals. In extremely small doses it is a throat irritant and causes coughing. As much as 5 per cent free nicotine in base oil has been applied to plants where there was adequate ventilation without much discomfort to the operator. Against most insects, 1 per cent free nicotine in oil is sufficient. A fog of this strength may cause slight throat irritation and headache if one remains in a closed greenhouse with the fumes for more than an hour. One per cent can be used outdoors with impunity and also in the greenhouse if there is enough ventilation.

It is possible to mask the nicotine odor with pine tar or creosote odors but they do not prevent the throat irritation common to all nicotine sprays.

One per cent free nicotine in oil has seemed less nauseating to some observers than a 1:800 nicotine sulfate spray.

Applicators.—Up to the present, use has been made of airplane equipment, blower vaporizers, compressed air and knapsack sprayers, for the application of atomized oils (French 1934, 1935). Ginsburg (1935) used a fog sprayer in many of his tests. All of this equipment is available commercially only to a limited extent, the prices asked are excessive and the equipment is not entirely satisfactory.

It was found here that for small-scale use, a continuous atomizer was

much more satisfactory than a continuous sprayer such as the type used by Ginsburg. This atomizer did not drip and gave a steady flow of extremely small droplets with little effort in pumping. Measurements of droplets size at a distance of one foot showed that the majority of them were less than 10 microns in diameter.

This continuous atomizer should have immediate commercial possibilities for household and garden use, and so is described in some detail. Its construction is shown in fig. 1. F represents the barrel, plunger and valve taken from an ordinary continuous sprayer. A is a metal air cham-

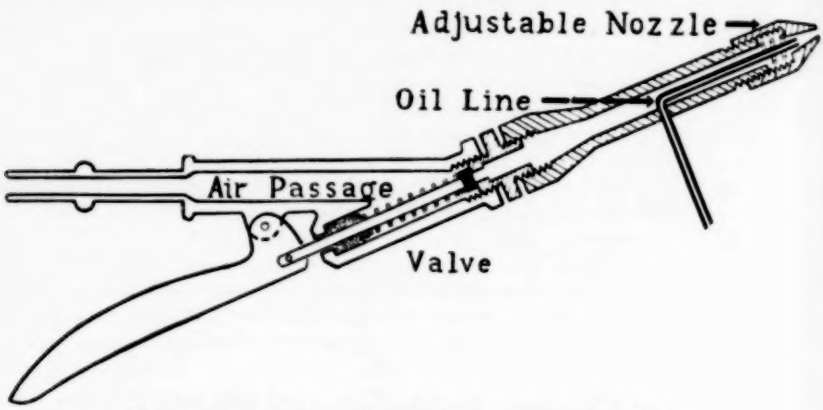

Fig. 2.—Construction of venturi tube, compressed air gun.

ber permanently fixed to the barrel. The liquid reservoir B is attached inside A. There is no communication between the two. Since B is subject to atmospheric pressure, there is a small hole in the screw filling cap E. C is a copper tube leading from the bottom of the liquid container to the air nozzle D. The orifices in both C and D are approximately .75 mm. in diameter. C projects slightly past the perimeter of the opening D.

In operation, the forward action of the plunger forces part of the displaced air through the opening D and compresses the rest of the air in chamber A, building up the pressure there. This pressure reserve, with the closing of the valve, causes a flow of air to continue through D on the return stroke of the plunger. The continuous stream of air from A across C causes a lower atmospheric pressure in C, effecting a rise of liquid to the tip. The high velocity of the air stream at the opening of C breaks up minute quantities of liquid into a fine penetrating fog.

Small two to four-gallon continuous sprayers for use in the garden may be easily adapted for use with atomized oils. An atomizer nozzle and liquid container may be screwed on the end of the spray rod and the two to four-gallon tank used as an air-pressure tank. One pumping up of such a three-gallon continuous atomizer was sufficient for 10 to 12 minutes operation.

For large-scale work, a nozzle is needed that produces a larger volume of fog and still breaks the oil into fine droplets. Several nozzles for this

purpose, built on the principle of the venturi tube, have been designed and used with both compressed air and steam, fig. 2.

Steam for aqueous spraying was tried in 1927 by Leiby (1927), who designed several orchard and truck-crop machines. A number of household electric atomizers make use of steam to break the insecticide up into a fog. The use of a steam jet to vaporize pyrethrum in oil was recently patented in Canada. In the work here, a special venturi-tube nozzle attached to an autoclave was used. At 12 pounds pressure, a good volume of fine fog was obtained. The fog was cold at 8 inches from the nozzle and no interference from water condensation was observed provided the nozzle was drained and heated first.

Summary.—Free nicotine dissolved in highly refined petroleum distillate shows promise as a horticultural spray. When correctly applied, it did not burn even tender plants and gave a high per cent kill of many insects with piercing-sucking and chewing mouth parts.

It is concluded that 1 per cent free nicotine in oil is suitable for field and greenhouse use with a minimum of discomfort to the operator and has a toxicity equivalent to .1 per cent pyrethrum in oil.

It was found possible to dissolve free nicotine in oil by two methods. The first is by adding 100 per cent free nicotine directly to the oil. The second is by shaking commercial free nicotine products, such as 50 per cent, with the oil base and then separating off the oil–nicotine from the settled water and impurities.

Nicotine in oil must be applied to plants in the form of a fine fog to avoid plant injury. Several new applicators have been devised and are described. One of these, a new hand continuous atomizer, appears to have immediate commercial possibilities.—1-5-37.

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Variability in Lead Residues on Apples

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In connection with studies on the relation of spray treatments to spray residue removal (Haller, *et al.* 1936) certain inconsistencies in the results indicated the possibility of considerable variability due to the application of the sprays or to the growth condition of the trees. In experimental spray treatments for orchard insect control the treatments are frequently replicated in various parts of the orchard because of possible differences in the insect population. The necessity for replication because of possible differences in coverage is not so well recognized. Spray treatments in 1935 for spray residue removal investigations were planned to give some information relative to the variability in spray deposit from replicate plots.

Material and methods.—Eleven spray treatments as outlined in table 1 were applied to Stayman Winesap apples in an orchard near Martinsburg, W. Va. Each spray treatment was replicated three times with one to three trees in each replication. More than one tree per replication was used in certain plots in order to obtain additional fruit for washing experiments. The trees were about 28 years old and trees of approximately the same size and with about the same size crop were chosen for each replication in each spray treatment. Replicate trees were generally adjacent and each spray application was made by the same operator and from the same tank of spray. Approximately 20 gallons of spray mixture were applied to each tree at each spraying. The entire crop was harvested from each tree during the commercial picking season and run over a grader set to select apples with diameters between $2\frac{1}{2}$ and $3\frac{1}{4}$ inches. Actually very few apples were discarded in this way, so that the apples used for analysis were quite representative of the trees from which they were picked. The fruit was mixed by the grading and variations in residue due to position on the tree were thus randomized within the samples.

[1] Also agent, U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

Table 1.—Outline of spray treatments given to plots near Martinsburg, W. Va., in 1935.

Plot No.	Cover Spray Number and Date of Application						
	May 27 1	June 12 2	June 26 3	Aug. 1 4	Aug. 10 5	Aug. 22 6	Sept. 7 7
1	LA*+B_4	LA+B_4	LA+B_4	LA+B_4	LA+B_4		
2	LA+B_4+MO	LA+B_4+MO	LA+B_4	LA+B_4	LA+B_4		
3	LA+B_4	LA+B_4	LA+B_4	LA+B_4+MO	LA+B_4+MO		
4	LA+B_4	LA+B_4	LA+B_4	LA+B_4	LA+B_4	LA+B_4	LA+B_4
5	LA+B_4	LA+B_4	LA+B_4	LA+B_4+CL	LA+B_4+CL	LA+B_4+CL	LA+B_4+CL
6	LA+B_4	LA+B_4	LA+B_4	LA+B_4+F	LA+B_4+F	LA+B_4+F	LA+B_4+F
7	LA+B_4	LA+B_4	LA+B_4	LA+B_4+MO	LA+B_4+MO	LA+B_4+MO	LA+B_4+MO
8	LA+B_4	LA+B_4	LA+B_4	LA+B_4+CL+MO	LA+B_4+CL+MO	LA+B_4+CL+MO	LA+B_4+CL+MO
9	LA+B_4	LA+B_4	LA+B_4	LA+B_4+F+MO	LA+B_4+F+MO	LA+B_4+F+MO	LA+B_4+F+MO
10	LA+B_8	LA+B_8	LA+B_8	LA+B_8+MO	LA+B_8+MO	LA+B_8+MO	LA+B_8+MO
11	LA+B_4	LA+B_4	LA+B_4	LA+MO	LA+MO	LA+MO	LA+MO

* LA, Lead arsenate 3 lb. to 100 gal.; B_4, Bordeaux mixture 2:4:100; B_8, Bordeaux mixture 2:8:100; MO, mineral oil emulsion 1:100 gals.; CL, casein lime spreader 1 lb.:100 gal.; F, *Fluxit* spreader 6 oz.:100 gal.

Lead was determined on the samples by a modification of the method described by Wichmann, Murray, Harris, Clifford, Louthrey & Vorhes (1930).

Table 2.—Lead residue at harvest on duplicate samples of Stayman Winesap apples from replicate spray plots.

Spray Treatment*	Replicate Plots and Av. No. Trees	Av. Grams Weight per Apple Dupl. Sample 1†	Dupl. Sample 2	Replication Av. 1+2	Grains Lead Residue per Lb. Dupl. Sample 1	Dupl. Sample 2	Replication Av. 1+2	Grains Lead Residue Av. A+B+C
	A,1	173	169	171	.079	.083	.081	
1	B-1	177	160	169	.080	.086	.083	
	C-1	170	162	166	.082	.085	.084	.083
	C-1	175	160	168	.094	.096	.095	
2	A-1	161	153	157	.100	.103	.102	
	B-1	154	147	151	.109	.120	.115	.104
	C-1	172	163	168	.097	.122	.110	
3	B-1	171	157	164	.089	.090	.089	
	A-1	151	144	147	.119	.123	.122	.107
	C-2	165	164	165	.121	.123	.122	
4	A-2	150	147	149	.117	.122	.120	
	B-2	136	133	135	.128	.127	.128	.123
	B-3	177	167	172	.112	.109	.110	
5	C,2	163	163	163	.103	.109	.106	
	A,3	154	153	154	.121	.130	.126	.114
	C,1	154	148	152	.108	.117	.113	
6	A,1	146	143	145	.109	.111	.110	
	B,1	146	142	144	.114	.121	.118	.114
	B,3	171	168	170	.143	.162	.153	
7	C,3	174	160	166	.144	.155	.150	
	A,2	163	158	161	.126	.147	.137	.147
	A,2	156	146	151	.145	.160	.153	
8	C,2	148	148	148	.140	.126	.133	
	B,2	151	144	148	.127	.118	.123	.136
	B,1	159	157	158	.130	.129	.130	
9	A,1	153	148	151	.157	.138	.148	
	C,1	147	139	143	.157	.145	.151	.143
	A,1	163	152	158	.126	.151	.139	
10	B,1	155	151	153	.123	.121	.122	
	C,1	151	146	148	.137	.135	.136	.132
	B,1	149	147	148	.228	.228	.228	
	A,1	153	139	146	.218	.220	.219	
	C,1	147	139	143	.180	.178	.179	.209
Average, all sprays	Largest			162			.130	
	Medium			156			.126	
	Smallest			149			.129	
	All replicates	159	152		.126	.130		

* For details of spray treatments see table 1.
† Duplicate samples consisted of at least 25 and usually 30 apples each.

Presentation of results.—The individual determinations of the lead residues at harvest are shown in table 2 and are arranged according to the average size of the apples.

Relation of size of apple to residue.—It will be noted in table 2 that the average size (weight) of the apples from some of the tree replications varied somewhat from other replications within the same spray treat-

ment. Likewise duplicate samples in each plot replication usually varied slightly in the average size of the apples. The apples in the duplicate samples having the larger average weight were 4.6 per cent heavier and the duplicate sample with the smaller apples averaged 3.2 per cent more residue. In 17 instances a difference in weight of at least 5 per cent existed between samples and the average difference was 7 per cent. The lead residue averaged 5 per cent more on these samples with the smaller apples. Thus it would appear that the variability in lead residue between duplicate samples was due for a large part to the greater surface area per pound in the samples with the smaller apples.

Table 3.—Analysis of variance of lead residue in grains of lead per pound of fruit at harvest in relation to duplicate samples of three replications of 11 spray treatments

Source of Variation	Degrees of Freedom	Mean Square	Ratio between Mean Square of Treatment and Mean Square of Experimental Error*
Total	65	.00112	
Between duplicates within replicates	33	.00005	
Between means of replicates within spray treatments	22	.00031	6.2†
Between means of spray treatments	10	.00641	20.7‡

* Snedecor's "F" value.

† Mean square between duplicates used as experimental error between replicates. Ratio of 2.4 required for odds of 99:1.

‡ Mean square between means of replicates used as experimental error between spray treatments. Ratio of 3.2 required for odds of 99:1.

The replications within spray treatments having the largest apples averaged 8.7 per cent heavier apples than the replications having the smallest apples. The lead residue, however, averaged more on the replication with the largest apples than on the replications with the smallest or intermediate-sized apples. Thus the variability between replications would appear to be due to factors other than the size of the apples from the different replications.

Experimental errors in relation to duplication and replication.—To determine the significance of the differences between replications, the lead analyses in table 2 are presented in table 3 by means of the analysis of variance according to the method described by Snedecor (1934). Sampling and analytical errors are present in the variations between duplicate samples. The low mean square between duplicates, table 3, indicates that the sampling and analytical errors are relatively insignificant.

The experimental error between means of replicates is represented by the variation between duplicates. The ratio of 6.2 between the mean squares of the replicates and the mean squares of the duplicates indicates that highly significant differences exist between replications, since a ratio of only 2.4 is required for odds of 99:1 according to the tables given

by Snedecor (1934). From the data in table 3 the standard error between replicates was found to be .0014 grain per pound. Differences greater than twice the standard error, or .0028, would be considered significant. According to this value all replications of spray treatments Nos. 2, 3, 5, 8, 9 and 11 differ significantly from each other and spray treatment 1 is the only one in which none of the replicates differ significantly, table 2. It is of interest to note that the replicates from each spray treatment that show the greatest difference range from three to 36 per cent and average 17 per cent greater residue on the replicate with the heavier load. The greatest difference (36 per cent) was between replicates A and B of spray treatment 3. In four of the 11 spray treatments the

Table 4.—Ratio of lead residues on replicates A and B at harvest and after various washing treatments.

Spray Treatments	Ratio of Replicates	Ratio of Lead Residues		
		At Harvest	Av. for 5 washes	Av. for 32 washes
1	B:A	1.03	1.11±.08*	
2	B:A	1.13	1.12±.04	
3	A:B	1.36	1.49±.06†	
4	B:A	1.07	1.06±.08†	1.15±.03*
5	A:B	1.14	1.01±.09	1.10±.03
6	B:A	1.07	1.01±.06	
7	B:A	1.12	1.08±.035	1.12±.03
8	A:B	1.24	1.24±.06	1.33±.02
9	A:B	1.14	1.19±.05	
10	A:B	1.14	1.13±.03	
11	A:B	.96	1.04±.06	

* Standard error.
† Average of four washing treatments; sample from one washing treatment lost.

maximum differences between replicates exceeded 20 per cent, and in only three cases was it less than 10 per cent.

Replicates A and B of all of the spray treatments were washed with five different washing treatments and these replicates of four of the spray treatments were washed with 32 different washing treatments in a flotation machine with solutions of hydrochloric acid, in which the time of exposure, concentration of the acid or temperature of the solution varied. The ratios of the replicates at harvest and the average ratios after washing are given in table 4. The significance of the differences at harvest are rather conclusively borne out by the fact that similar differences usually existed after the various washing treatments.

Discussion.—These results indicate that the spray cover on apples may vary greatly between trees even though the spray is from the same tank and applied by the same operator. This introduces a rather large experimental error into spray treatments for insect control or spray residue removal investigations that frequently is not taken into account. Although the analysis of variance of the data, table 3, showed that highly significant differences existed between the spray treatments it is likely that smaller differences might have been considered significant had

replicates not been used. According to these data the standard error between means of spray treatments was .014 grain per pound and differences of .028 would be necessary to be considered statistically significant. On this basis for example, spray treatment 1 that averaged 0.83 grain per pound was not significantly different from spray treatments 2 (.104 gr./lb.) or 3 (.107 gr./lb.), and spray treatment 4 (.123 gr./lb.) differed significantly from 1 and 11 but not from any of the other spray treatments that ranged from .104 to .147 grain per pound.

Summary and conclusions.—Eleven spray treatments were applied to Stayman Winesap apples. Each spray treatment was replicated three times on adjoining or closely adjacent trees. The fruit from each replication was kept separate and duplicate 30-apple samples were taken from each replication for the determination of lead residue at harvest. Additional analyses of duplicate 15-apple samples were made with certain of the lots after various washing treatments.

Considerable variation was found to exist between determinations within spray treatments. Statistical examination of the data showed that variations between duplicate determinations within replicates, representing sampling and analytical errors, were relatively small and due in part to the size of the apple in the samples. Variations between replicates within spray treatments would represent differences due to the application of the sprays or to differences in the growth condition of the trees. The variation between replicates both at harvest and after washing was found to be quite large and not attributable to the size of the fruit. These variations introduce a serious error that should be taken into account in the comparison of spray treatments.—1-7-37.

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Methods and Equipment for Laboratory Studies of Insecticides

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In July 1935 the Sherwin-Williams Company established an insecticide research project at the Ohio State University. It was planned that problems in the general field of lead arsenate substitutes should be studied.

[1] Early publication of this paper has been secured by payment of the printing charge.

Early in the investigation it was decided that considerable time should be devoted to development of methods and equipment to be used in the various phases of the insecticide study. The aim in this part of the work has been to build up an insecticide testing laboratory in which plants and insects for test purposes can be raised under standardized conditions the entire year, and not be limited to the growing season or influenced by varying environmental conditions.

With this aim in mind work has been conducted along the following lines:

(1) Equipment of an indoor culture room in which the temperature, humidity and light can be controlled and kept constant the entire year.

(2) Selection of a wide variety of insects for test purposes largely from species of economic importance, and including, as far as possible, one or more representative species of the more destructive insect families.

(3) Development of methods and equipment for rearing these insects under controlled conditions for as great a portion of the year as possible and for as great a portion of their life cycle as possible.

(4) Development of methods and equipment for providing a continuous supply of plant material, for insect food and chemical injury tests, that varies as little as possible in quality during the different seasons of the year.

(5) Minimizing the amount of labor involved, making conditions more uniform and making duplication of work easier, by using automatic equipment and simplified methods wherever possible.

Some of the results of the study to date are presented in this paper.

Indoor culture room.—An essential part of a testing laboratory of the type described is a plant and insect culture room in which uniform environmental conditions can be maintained.

With modern air-conditioning equipment and insulation materials it is not difficult to fit up a room in which constant temperature and humidity can be maintained continuously. Baker & Arbuthnat (1931) give a detail description of an incubator room in which temperature is lowered by use of ice. If refrigeration equipment is not available, a basement, or preferably a sub-basement room, can be equipped at comparatively little cost, to maintain uniform conditions for all except the hot summer months.

For this study a basement room 24 feet long, 12 feet wide, and 10 feet high (2880 cubic feet) was selected. The single window was covered with fiberboard to exclude all outdoor light, artificial light being used entirely. This was done to eliminate the effect of seasonal variations in quality, intensity and daily duration of sunlight.

Temperature Control.—Outdoor air is used to keep the room cooled to the desired temperature. For most of the plants and insects raised a temperature of 25° C was found to be satisfactory and has been adopted as standard. The radiator in the room is so adjusted that it provides sufficient heat to raise the temperature to just above 25° C. An eight-inch electric fan, placed in a box built into the window, was connected with a thermostat in such a way that outside air is blown into the room whenever the room temperature rises above 25° C. A second ther-

mostat located outdoors was connected with the system in such a way that the fan will not operate if the outdoor air temperature is above

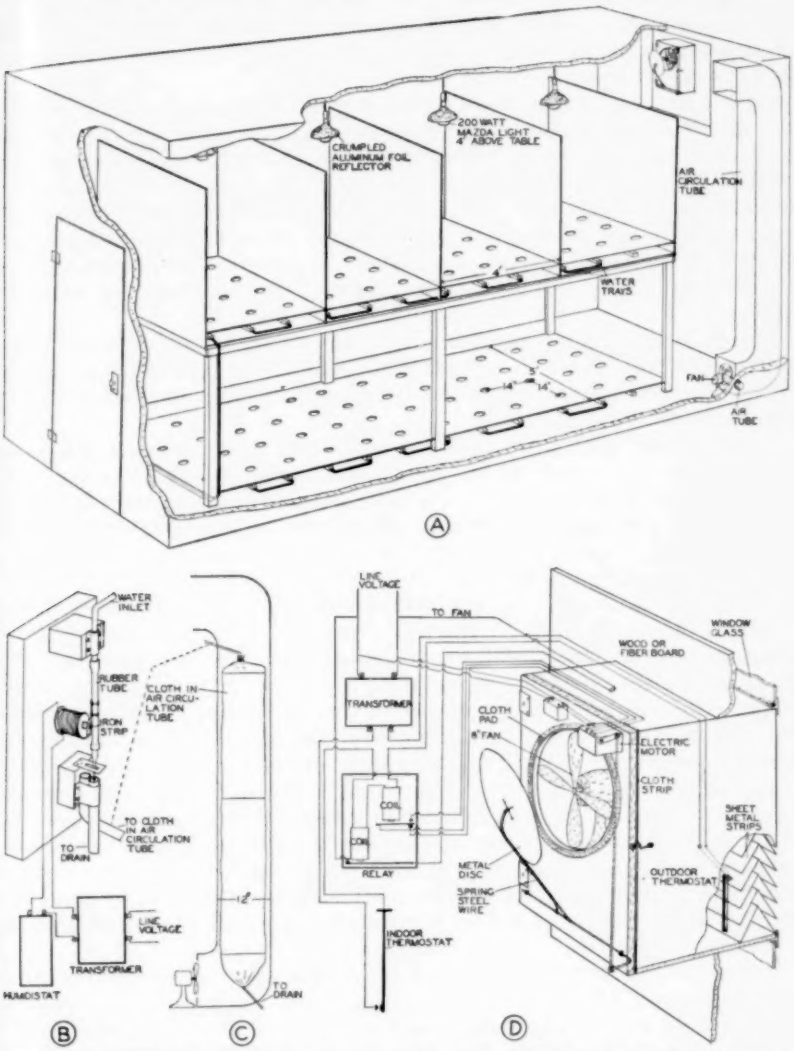

Fig. 1.—A, View of indoor culture room, showing relative position of temperature control unit, air circulation tube, lights, and culture table. B, C, Details of humidity control unit. D, Details of temperature control unit.

25° C. A tight-fitting damper located in front of the fan and operated by a small electric motor opens when the fan starts and closes when the fan stops. This is necessary to prevent excessive air leakage during ex-

tremely hot or cold weather. The motor is of the type used for automatic opening and closing of furnace dampers. This one was made by the Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota, (Type M-26). Any other type of closing arrangement that will serve the same purpose can be used. Figure 1D shows the details of this temperature control unit.

Air is circulated in the room by the arrangement shown in fig. 1, A,C. It consists of a tall tube 14 inches square with an eight-inch fan placed at the bottom. This blows the cooler air from the floor level across the room at the ceiling level, reducing the temperature variation throughout the room to less than 1° C. The tube can be constructed from heavy corrugated cardboard and gummed paper tape. A more complex air circulation system might still further reduce the temperature variation, but for the purposes of this study this simple unit has proved quite satisfactory.

A high-capacity fan is not necessary, an ordinary 8-inch table fan being sufficient. If the motor overheats with continuous operation, it can be cut to about half speed by connecting resistance in series, and will still give sufficient air circulation.

It was found that at times when the temperature balance was such that little or no outdoor air was blown into the room, the air in the room became stale. To overcome this, a tube 4 inches in diameter was placed through the wall, one end opening into a large adjoining laboratory and the other end opening just behind the fan of the air circulation tube, fig. 1. This provides a continuous flow of fresh air into the room.

Humidity Control.—A relative humidity of 55 to 60 per cent was found to be satisfactory. A relative humidity of 70 per cent or above favors the development of insect diseases, while below 50 per cent both plant and insect material dries out too readily. During warm rainy periods, the humidity sometimes rises to 70 per cent or above, and no attempt has been made to dehumidify the air. However, during the greater portion of the year the humidity of the air in this basement is below 55 per cent. The unit shown in fig. 1, B and C is used to keep the humidity up to 55 per cent. When the humidity falls below 55 per cent water drips onto a long piece of cheesecloth, hung in the air circulation tube. Other types of humidity control can be used, several of which are described by Peterson (1934). The relay coils and transformer described on his plate 138 are satisfactory for these temperature and humidity control units.

Light.—Ordinary 200-watt tungsten lights (*Mazda*) are used in growing the plants. Ultra-violet lamps were tried, but no changes in plant growth were noted. The lights are placed 4 feet above the table and 4 to 6 feet apart. Aluminum foil, from boxes of 5×7 photographic films, make highly efficient reflectors. The foil should be crumpled to diffuse the reflection, and then shaped into the form shown in fig. 1. This reflector increases the light intensity by two-thirds.

The use of a single light of 200 watts results in much more desirable plant growth than the use of four 50-watt lights placed at the corners of a 3-foot square.

The lights are connected with a time clock, being on 19 hours a day. If the light period is made too short the plants become tall and spindly.

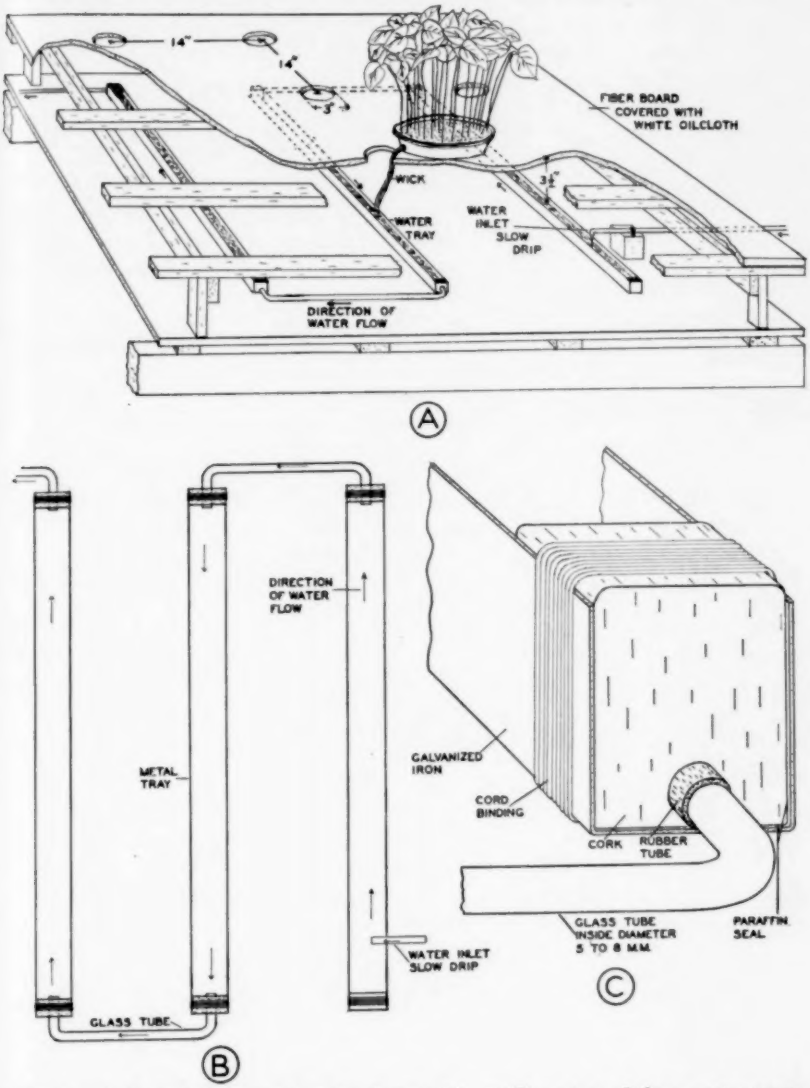

Fig. 2.—A, Details of a section of culture table. B, Top view of three water trays. C, Details of end of water tray.

A General Electric time clock switch, type 17-A, is used.

CULTURE TABLE.—A large double-deck table was built in the culture room, as is shown in figure 1, with lights above each deck. The frame-

work was made of two by four-inch and one by two-inch strips of lumber. Fiberboard (*Masonite*) one-half inch thick, covered with white oilcloth, is used for the table top. This board works easily and does not warp badly if it becomes wet. The two decks are spaced 4½ feet apart, as this distance is necessary for efficient use of the lights of the lower deck. On the upper deck, whitewashed fiberboard panels four feet high and five feet long were placed at four-foot intervals as shown in fig. 1. These prevent the outside air from the temperature control unit from blowing directly across the plants on the upper deck. They also divide the table into convenient units for experimental work.

Plant culture method.—A convenient and efficient means of growing large quantities of plant material in this culture room was developed. It involves the use of shallow trays of sand kept moist by means of wicks extending to a water surface below the tray.

Plant Growth Trays.—Flower pot saucers make cheap, durable and satisfactory trays. Saucers 7½ inches across the top are a convenient size. A hole one-half inch in diameter is made in the side, near the bottom, for the wick. Waterproofing the saucers keeps them in much better condition and reduces the evaporation of moisture. It has no apparent affect on root aeration. Paraffin is a good waterproofing material. The method of application of the paraffin is as follows. The saucers are held in paraffin at 100° C until the paraffin that first solidifies on the clay surface has just melted. Then they are removed, drained a few seconds, dipped in cold water for a few seconds, removed, wiped smooth with a dry cloth, and replaced in cold water until thoroughly cooled. This leaves a thin layer of paraffin over the entire surface that will last a long time. If the layer is too thick it will soon chip off. If the saucers are kept in hot paraffin until they become quite hot, and are allowed to cool in the air the paraffin will be absorbed, leaving no layer at the surface. This type of treatment is not satisfactory.

Shallow aluminum pans, or tin pans coated with aluminum paint, also make satisfactory trays.

Growth Medium.—Sand is more satisfactory than ordinary soil. Sand is easier to handle, usually contains fewer decay organisms, and allows more root aeration. All these points are important where seeds are planted in large numbers close together.

Various plant culture solutions were tried, but none proved to be any better than tap water under the indoor growth conditions.

Methods of Watering.—An automatic watering system was developed that greatly reduces the amount of labor necessary for growing plants, and also results in much greater uniformity of plant growth than can be obtained by hand watering.

It involves the use of a wick, made of a strip of absorbent cotton, leading from the sand to a water supply below the tray. Water travels up the wick by capillary action and keeps the sand moist. The water content of the sand can be regulated by varying the vertical distance between the bottom of the tray and water level. A distance of 3½ inches was found to be the most satisfactory.

By means of the system shown in figs. 1 and 2, water, at a constant

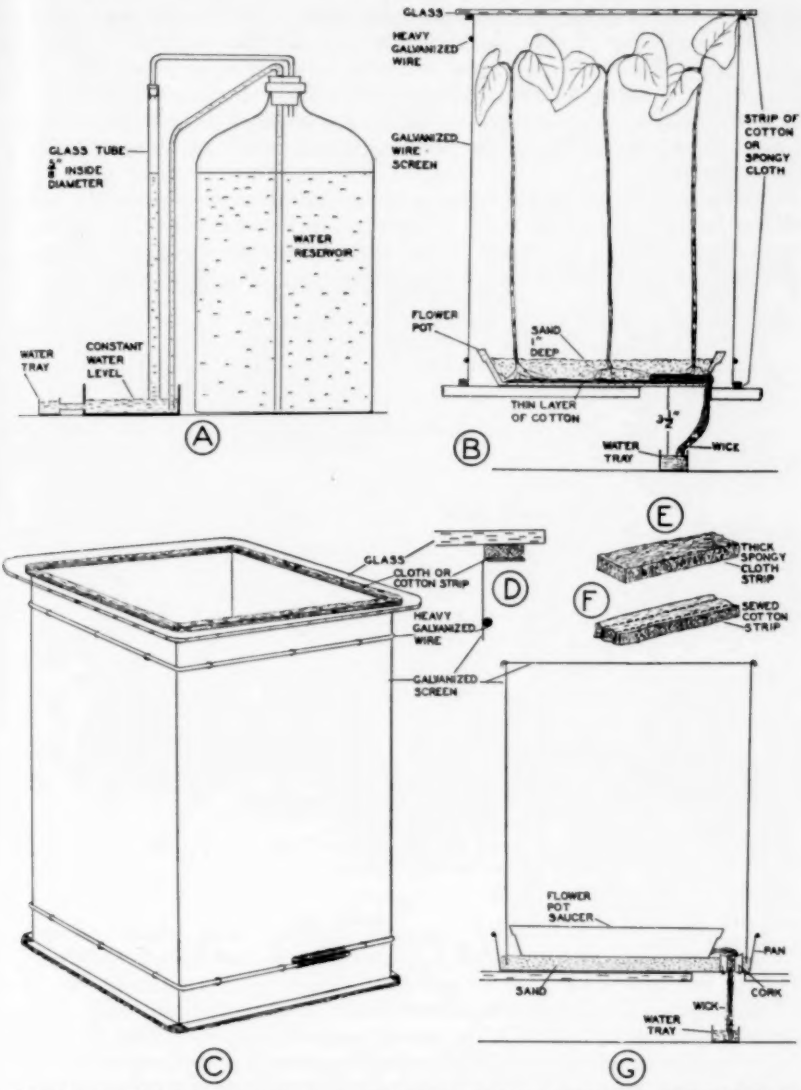

Fig. 3.—A, Details of an arrangement for maintaining a constant water level. B, Section of a cage made of wire screen, heavy galvanized wire, cloth and glass, placed over tray of plants on culture table. C, General view of the cage shown in B. D, Enlarged section showing relationship between the screen, cloth strip, and glass. E, A strip cut from thick, spongy table padding. F, A strip made of sewed cotton batting. G, Section showing flower pot saucer on layer of sand in cage.

level below the table top, is supplied to all parts of the table. The system consists of a series of long galvanized-iron trays 1 inch wide and

1½ inches deep, connected in series by glass tubes as shown in figs. 1 and 2. The tubes should be attached as near the bottom of the tray as possible. Glass tube siphons can also be used to connect the trays. Tap water is allowed to drip slowly into a tray at one end of the series. It flows through the trays and the excess runs off into a drain at the other end of the series. This system provides a continuous supply of fresh water.

Where it is not practical to have a continuous-flow system, the set-up shown in fig. 3A can be used. Water in the constant-level container is connected with a water tray at one end of the series. There is no drain and water flows into the trays only as fast as it is used.

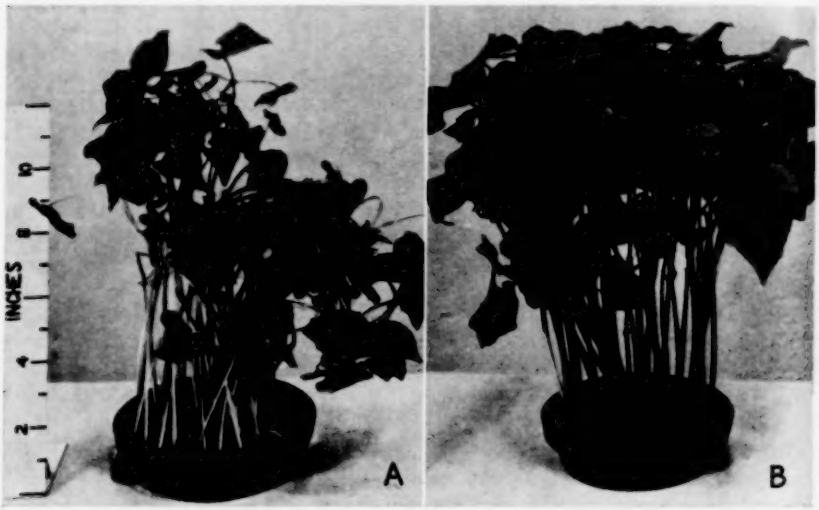

Fig. 4.—A, Pinto beans grown under artificial light. An undesirable growth. B, Cranberry beans (London Horticultural variety) grown under artificial light. Stems straight and leaves large.

TYPE OF PLANTS GROWN.—In the culture room plants are grown for two purposes: use as insect food, and use as test plants for chemical injury. For insect food the object is to obtain the maximum amount of satisfactory food in a limited area in the minimum time. When a seed sprouts there is an initial high rate of growth that results in the formation of the primary leaves. After this the growth rate slows down. Thus to get a large amount of foliage in a short time, seeds are planted thickly and only the primary foliage used. Under the 200-watt *Mazda* lights plants do not grow to maturity but die after the food supply in the cotyledons is exhausted. Most plant species will remain in a usable condition for two to three weeks after the primary leaves are formed.

For chemical injury tests the plants are grown either singly in small 2-inch pots, or 20 to 25 in 7½-inch saucers, to allow the development of large perfect leaves.

In general, plants with large seeds do better under these artificial conditions because of their greater food reserve. Some large-seeded plants, however, do not make satisfactory growth and the selection is limited to those that do. Thick plantings of certain small-seeded plants, plants, such as rape, make a satisfactory food for some insects.

It has been found that within a given plant species certain varieties and strains make a much more desirable type of growth than others. This is very marked with beans. The varieties used at first grew very

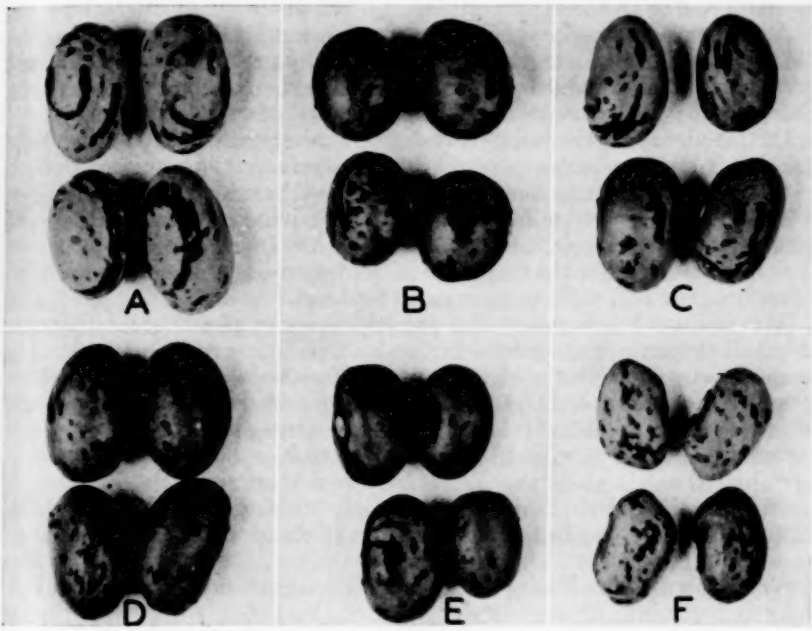

Fig. 5.—Bean seeds. A, A large cranberry bean obtained from a grocery store, excellent growth. B, London Horticultural variety, excellent growth. C, Another cranberry obtained at a grocery store, fair growth. D, French Horticultural variety, poor growth. E, Dwarf Horticultural variety, poor growth. F, Pinto, poor growth.

poorly. There was much variation in the size of the leaves, most of them being small and curled. The stems did not grow upright, but twisted into a tangled mass. The Pinto bean, shown in Fig. 4A, illustrates this type of growth. A number of other varieties were tried in the hope that a better one would be found. Such a variety was found in the cranberry bean, also called the Horticultural variety.

Not all strains of the cranberry bean are satisfactory. One good strain is the London Horticultural, obtainable from A. J. Brown and Sons, Inc., 9–11 Ionia Ave., Grand Rapids, Mich. Figure 4B illustrates the type of growth made by this strain. The stems are heavy and straight and the leaves large and fairly flat. Figure 5B shows the appearance of the seed.

In general the larger the bean seed the better the type of growth, but there are exceptions to this. For example the French Horticultural, which has large seeds, fig. 5D, develops a very tall stem and small leaves. Actual trial is the only way to determine whether a given lot is satisfactory.

Some lots of cranberry bean seed purchased at grocery stores have proven satisfactory. Figure 5, A and C show two of these. The large light-colored seed, fig. 5A, was exceptionally good, having very sturdy stems and large flat leaves. The seed shown in fig. 5C was intermediate in quality. The Dwarf Horticultural, fig. 5E, was very unsatisfactory.

A difference in variety of peas was also noted. The smooth-seeded field peas such as the Alaska make tall spindly growth, with very small leaves, while the wrinkled-seeded garden peas such as the Potlatch make short, stocky growth with fairly large leaves.

Of the cucurbits, the large-seeded Hubbard squash proved much better than summer squash, pumpkin and cucumbers.

Field corn makes excellent growth, but is rather short lived. It reaches a height of 10 to 12 inches in 10 days after planting, remains in good condition about a week, and then begins to lose its color and die.

Some other plants that have been grown successfully in the culture room are peanuts, rape, cowpeas and soybean.

Method of Planting.—The growth of many plants close together in small trays requires special methods of planting. In most cases it is necessary to allow the seeds to sprout before being planted. If a thick planting of the dry seed is made, those that do not germinate soon decay, resulting in an undesirable condition in the sand of the tray. In a given lot of seeds some germinate much sooner than others. Planting newly germinated seeds gives the plants an equal start, resulting in greater uniformity of growth. This applies mainly to large-seeded plants, such as beans, corn, squash and peas, and not to small-seeded plants such as rape.

The procedure used in germinating seed is as follows. They are first soaked in water until swelled to full size. Soaking should not be continued longer than this, or reduced germination and vigor will result. For squash and peas, four to nine hours is sufficient. For beans the time depends on the imperviousness of the seed coat. If the coat is pervious, four to six hours soaking is sufficient. However, different lots vary in this respect. In some lots all the seed will swell in four to six hours. In others there is no uniformity, some of the seeds swelling right away and the rest reaching full size over a period of one to two days. In such a case it is necessary to sort out the swollen seeds several times a day to prevent their being injured by oversoaking.

The temperature of the water should be between 80 and 90° F, and the times given apply to this temperature range. If the temperature is much less than 80° F the rate of swelling is greatly reduced with a consequent reduction in uniformity of sprouting.

The swollen seeds are placed about one to two layers deep in the bottom of a pan between thick layers of some moist absorbent material. Pads made of several thicknesses of wet newspapers are excellent for

this purpose. They can be used once and then discarded, with no accumulation of mold organisms, as is the case with cotton pads that are used continuously.

It is best to plant the seeds as soon as the tip of the sprout appears. If the sprouts of such seeds as beans, squash and others which on development push the cotyledons out of the ground become much over one-half inch long before being planted, the cotyledons are apt to become tangled with the roots, resulting in poor growth. If seeds are allowed to develop long sprouts, they should, when being planted, be carefully placed in the sand with the sprout down. The seeds of such plants as corn and peas do not come out of the ground on development, so that planting as soon as sprouts appear is not so important.

The method followed in planting the sprouted seeds is as follows. A wick, made of a strip of absorbent cotton 7 inches long and three-eighths inch in diameter, when wetted and the excess water pressed out, is pushed through the hole on the saucer. A 4-inch square pad of absorbent cotton is dipped in water and the excess water is pressed out. From this thin layers of cotton can be peeled. A single thin layer of this cotton is placed on the bottom of the saucer in contact with one end of the wick. This is covered with one-half to three-quarters of an inch of moist sand. The seeds are distributed on this and covered with a layer of moist sand one-eighth to one-quarter inch deep.

In the case of beans, if a dense growth of foliage is desired, 40 to 60 seeds (depending on the size of the seed) are planted in an area 7 inches in diameter. Corn can be planted so that the seeds are touching each other. Squash seed is planted at the rate of 50 to 60 to an area 7 inches in diameter. When squash seeds are planted this thick they should be placed on edge in rows or poor growth may result.

The trays are then placed in a humid cabinet until the plants have pushed out of the ground. Then they are placed on the culture table under the lights and the wicks are connected with the water system.

The use of the humid cabinet is quite essential. If such plants as beans and squash grown in the thin sand layer are allowed to come up in a room or cabinet where the relative humidity is not near 100 per cent, the seed hulls dry out and many plants do not shed them. They must then be removed by hand. If the humidity at this state is such that the hulls do not dry out, most of them will be shed.

In the humidity cabinet the sand is not cooled by evaporation, with the result that growth is more rapid. The use of the cabinet also conserves table space. A humid cabinet of the type figured by Waters & Witman (1937) is satisfactory.

Most plants will be ready to use in eight to 12 days after planting. Beans are used when the first pair of leaves has reached full size. If it is necessary to hold them for several days after they have reached this stage, the central shoot that grows up should be cut off. Otherwise a tangled mass of shoots will develop in a few days at the expense of the food in the primary leaves.

With squash plants it is not necessary to pinch out this central shoot. These plants develop one and sometimes two large secondary leaves.

Greenhouse culture methods.—In addition to the indoor culture room, greenhouse space is necessary for the year-round rearing of some of the test insects. The food plants for some cannot be raised under the artificial light. Natural sunlight conditions are necessary for the mating and oviposition of certain species.

In the greenhouse used in this study a number of modifications of the usual equipment and methods were made to lessen the labor requirement and improve the plant and insect growth conditions.

Temperature Control.—By means of a fan and thermostat arrangement it is possible to control the temperature for a large portion of the year. A glass pane was removed and an 18-inch ventilator fan (General Electric type T) was put in its place in the wall near the top at one end of the greenhouse. The fan was so set that it would blow air out of the house when in operation. A closing arrangement made of two light metal panels was placed over the opening. The panels open when the fan is in operation and close when the fan stops. The fan is controlled by a thermostat hung below a shade in the center of the greenhouse, set so that the fan operates whenever the temperature rises above 25° C. A large size furnace damper control motor (Minneapolis-Honeywell Type D) was connected so that it opens a top ventilator at the opposite end of the greenhouse from the fan whenever the fan operates. The mechanical attachment between the motor and the ventilator was made adjustable so that it could be set to open the ventilators wide in warm weather and only slightly in cold weather.

In addition to the above there should be thermostatic control of the heat output of the radiators. This thermostat should be set to operate at about 1° C below the fan thermostat. The fan will then blow out warm air only when the house is heated to above 25° C by sunlight or outside air. The radiators will always be turned off when the fan is in operation, with a consequent saving in the heating cost of the house. With this arrangement there is little risk of the greenhouse overheating as the result of sudden changes in outdoor conditions.

Automatic Watering.—Automatic watering of plants is used in the greenhouse. It saves much time, results in much more uniform growth of plants, and insures against loss of plants from lack of water. The elimination of hand watering results in a more desirable humidity condition in the greenhouse. After extensive hand watering there is a period of extremely high humidity, which promotes mildew, mold and insect diseases. During hot, dry days, however, the humidity must be raised by hand watering of the plants and floor, or by some other means. Atomizers or mist-heads placed at the air intake of the greenhouse and controlled by a humidistat will take care of the humidity problem during dry weather.

Two types of watering systems have been used. The wick and water tray type described for the indoor culture room, or some modification of it, is quite satisfactory. The saucers or pots of plants can be set on wooden slats 3 to 4 inches wide, laid across the top of the bench, with wicks extending to water trays below. The use of movable slats makes the system quite adjustable to take care of different sizes of pots and saucers.

Where greenhouse space is limited, overhead shelves suspended 3 to 4 feet above the benches and made of three-eighths-inch iron rod and half-inch-mesh hardware cloth, can be set up with an automatic watering system and used for raising plants. A shelf of this type casts a minimum of shade on the bench below.

A second system of automatic watering has been used. The soil in the benches was removed and replaced with a 3-inch layer of sand. Water tubes were arranged so that there was a slow drip of water onto the sand at points every 3 to 5 feet along one side of the bench. Below the point where water drips onto the sand, the sand was removed, and a 6-inch hole cut through the bottom of the bench. A board with several one-eighth-inch holes drilled through it was nailed over this opening on the lower side of the bench and the sand was replaced. This arrangement provides a sand level lower than the general level of the sand in the bench and drainage through it prevents the sand from becoming too wet. This greenhouse has a sand floor and the drainage water is allowed to fall on it. In a greenhouse with a concrete floor a special pipe system to collect the drainage water would be necessary.

All plants other than those grown in saucers and watered by wicks are grown in sandy loam in ordinary flower pots. The lower part of the pots are set 2 or 3 inches deep in the moist sand. Except on hot days when the evaporation rate is high it is not necessary to water the plants by hand.

Insect Food Plants Grown from Seed in the Greenhouse.—For plants such as beans and corn the system described for the indoor culture room is used, including germination before planting, use of saucers, sand, wick watering, and starting in a humid cabinet. Such plants remain in a usable condition much longer in the greenhouse than in the culture room. A small stock of these is usually kept growing in the greenhouse to serve as a reserve in case of a shortage of indoor plants. The central shoot of bean plants should be kept cut back as recommended for beans grown in the culture room. The secondary leaves of squash should be allowed to develop. Corn plants do not last long if planted thickly. However, if planted 8 or 10 seeds to a 7-inch saucer or pot of sandy loam, they will develop into larger plants, and serve as reserve food for several weeks.

In the late fall and winter months when the days are short and the light intensity is low, the growth rate of most plants in the greenhouse is much reduced. During this period, especially when there are many cloudy days, the cranberry bean makes better growth than other beans, just as it does under artificial light. During the rest of the year, however, several other bean varieties, such as Burpee's Green Stringless, are just as satisfactory.

Use of Root Crops to Supply Insect Food.—During the winter months it is not practical to grow plants such as cabbage, turnip, beet and celery to full size from seed unless a very large amount of greenhouse space is available. Large quantities of the foliage of plants with bulbous roots can best be obtained by using roots grown in the field during the summer and potted and placed in the greenhouse in the fall. The growth

from these roots is comparatively rapid, because of the large reserve of food present and large amount of root development.

For the crucifer family, rutabaga and turnip are good. For the beet family red beets, sugar beets, mangels, swiss chard and perpetual spinach do well. Of these, perpetual spinach will produce the greatest volume of leaf tissue for the bench space occupied. This plant is not like ordinary spinach, but is a close relative of swiss chard, being larger and more vigorous, and developing a root as large as that of a sugar beet. The seed can be obtained from Stumppe and Walter Co., corner Church and Warren Streets, New York City. In a planting of it two types of growth will be found. One type has very large wrinkled leaves. These are suitable for rearing work. The other has leaves that are considerably smaller but are flat and more suited to spraying for toxicity tests. Both types should be included when potted in the fall.

Mangels also make excellent growth. They tend to send out many shoots instead of just one. If large leaves are desired, all but one shoot should be kept picked back. If many small leaves for insecticide tests are wanted then several shoots should be allowed to develop.

Sugar beets, red beets and swiss chard make fair growth.

These root crops should be planted outdoors early in the spring and allowed to develop until fall. The beet group does best if potted just after the first light frosts. This seems to break dormancy and stimulate growth. For rutabaga and turnip the frost is not necessary. All the roots should be in before a heavy freeze occurs. Roots can be stored and brought out and used later in the winter. If stored they keep best at a temperature just above freezing. The storage condition should be such that the roots remain solid and turgid, and do not dry out. Where there is sufficient space they can be stored already potted in moist soil. They can also be pitted outdoors under straw and dirt. When potted for the greenhouse from the field, all the leaves except those 3 or 4 inches long should be removed, taking care not to injure the central shoot. For storage all but a central shoot 1 to 3 inches long should be removed. This should not be broken in packing for storage. The leaves should be pulled off at the base by hand, and not cut with a knife, as the bases of the stems that are left usually decay, and this may spread through the root. A sandy loam is much more desirable than a heavy loam for potting the roots.

It is not necessary to use pots much larger in diameter than the roots. For a rutabaga root 4 inches in diameter, a pot 5 inches in diameter is large enough. Mangel roots 5 inches in diameter and 12 inches long do very well in pots 6 inches in diameter and 6 inches deep. Perpetual spinach roots are usually somewhat branched and may require 8 to 10 inch pots. It is not necessary to set the roots of any of the above-mentioned plants deep in the soil. As long as the lower quarter to third of the root is in the soil they grow well.

All of these types when brought from storage tend to send out a large number of sprouts. These should be kept picked back to one or two sprouts or a tangled growth will result.

The foliage should not be allowed to remain on the plant until it

begins to show signs of aging. Regardless of whether there is use for the foliage or not, the plants should be gone over weekly and all leaves that show any yellowing or withering should be removed. If this is not done, the growth becomes static, and is slow to pick up when leaves are removed. Also it is not good practice to remove too many leaves at one time. The stock of plants should be such that the desired number of leaves can be obtained by picking 1 or 2 from each of a number of plants. If all but a few small leaves are removed, it takes a long time for the plant to recover, since the rate of growth is dependent on the photosynthetic area present. For this reason it is not good practice to allow the insects to feed directly on the potted plants, because they may destroy all the leaves, including the central bud.

If it is not possible to grow a supply of roots, they usually can be purchased from gardeners. Several types of roots, depending on the locality, can be purchased on the market through the winter.

Vegetable Market as an Insect Food Source.—In many vegetable markets green leaves of spinach, celery and various members of the crucifer family, carrot tops and roots, and other plants are usually available the year around. Ordinarily there is no spray residue on such plants, but this possibility must be considered. The leaves should be washed well before being used. If the vegetable market is used as the chief source of food, a small stock of plants should be kept growing in the greenhouse to serve as a reserve, in case some of the leaves needed should not be available for a short period.

Insect rearing cages.—In the rearing of a number of species of insects it is necessary to have a variety of types of cages to fit the requirements of the individual species. A cage should be such that it keeps the insect under optimum growth conditions, and requires a minimum of labor for feeding and making transfers. The following is a description of some cages that have proven useful in this study.

By the use of galvanized-wire screen and heavy-gage galvanized-iron wire it is possible to make a basic framework for many types of cages, eliminating the use of wood or other supporting structures. Figure 3, B and C illustrate one type. A rectangle 9 inches square and 16 inches long, open on both ends, is made of screen and heavy wire. The edges of the screen at the top and bottom of this rectangle are bent outward three-eighths of an inch, at a right angle, and to this edge is fastened a narrow strip of some thick spongy cloth such as heavy blanket, table pad material, or strips of cotton sewed in the form shown in fig. 3F. If these strips are fastened on with rubber cement they will not come loose in moist situations. This cage can be set over a plant on a table top or some other flat surface, and a glass plate laid on the top as a cover. The spongy cloth acts as a seal between the screen and table and the screen and glass. A top made of a rectangle of heavy wire, a little large than the top of the cage, and covered with cloth or screen, can be used in place of the glass plate. A permanent screen top can be held in place by forcing the ends of the wires of the screen sides through the screen top and bending them over, as shown in fig. 3G. If it is desired to set the cage in soil or sand the lower edge can be made plain as shown also in fig. 3G.

Cages of this type can be made up to several feet in dimension. They have the advantage of being easy to make, adaptable to a wide variety

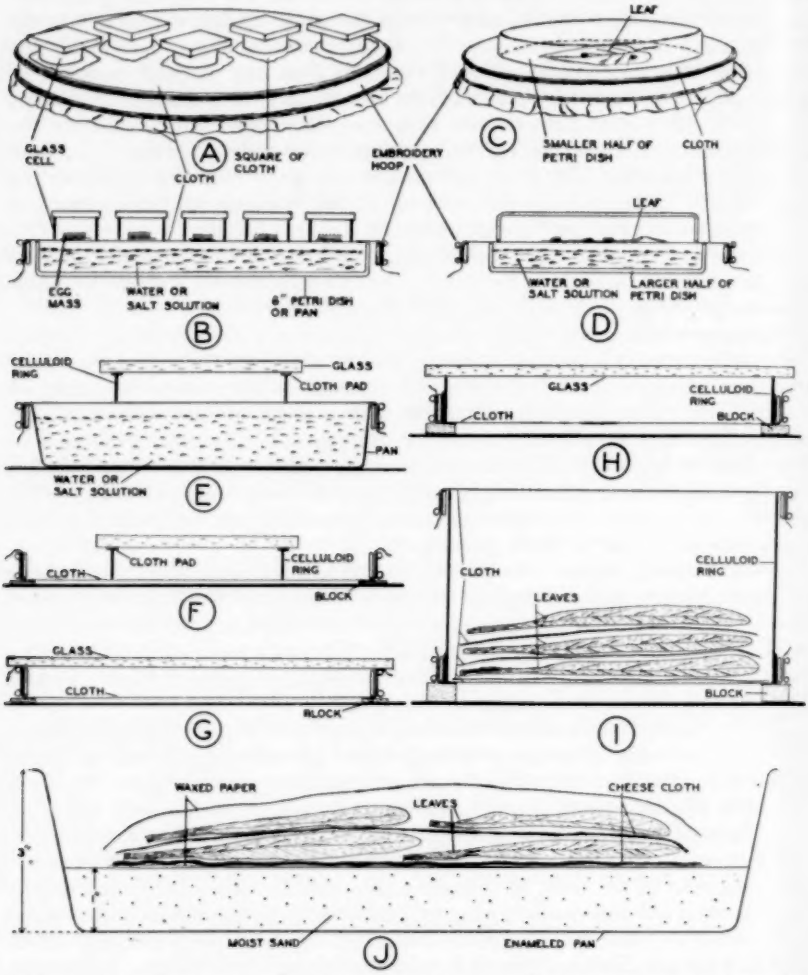

Fig. 6.—Insect rearing cages. A, B, General and sectional views of an egg incubation cage. C, D, General and sectional views of cage for egg incubation and early larval stages. E, Sectional view of alternate type of cage for egg incubation and early larval stages. F, Cage for early to middle larval stages. G, H, Cages for early to middle larval stages or for middle to late larval stages. I, Cage for larvae in latest stages. J, Pupation cage for insects that will pupate in sand.

of uses, light in weight, cause a minimum of shading of plants in the cage, provide a maximum of aeration, and make it easy to locate the insects in the cage.

In the culture room the saucer of plants is connected to the water system and covered with a cage as shown in fig. 3B. A sheet of fiberboard with a small hole made in it for the wick can be placed between the cage and table, making it possible to move the cage about without opening it. If a movable sand-bottom cage with the wick arrangement is desired, the type shown in fig. 3G can be used.

The rigidity of the cage varies with the mesh of galvanized screen used. Sixteen-mesh gives the maximum rigidity, smaller and larger meshes, excepting hardware cloth, being less rigid. For very small insects, a cage made of 16-mesh screen can be lined with cheese cloth.

With the above-described materials it is possible to make a large variety of useful cages for indoor, greenhouse, or outdoor use.

A wide variety of cages of another general type can be made by combinations of celluloid, embroidery hoops, cloth, glass plates, screen, petri dishes and small pans. Figure 6 illustrates a number of these. Many other combinations are possible. In these cages the humidity and aeration can be regulated to almost any desired degree. Larvae that ordinarily are considered messy to handle, because of accumulation of wet frass material, can be reared under comparatively dry and clean conditions with a minimum of labor involved. Loose leaves, picked from stock plants or obtained at a vegetable market, are used, eliminating the the necessity of placing in the cage potted plants or plants with the cut end of the stem in water bottles.

These cages can be used for the egg and early larval stages of a great many insects. For the latter larval stages, their use is limited to types that develop well at a high humidity, such as cutworm, armyworm, bean beetle, Colorado potato beetle and fall webworm. Those that are highly susceptible to disease, such as imported cabbage worm, cannot be handled in this manner.

Figure 6, A and B illustrate a cage useful for holding egg masses during the incubation period. The egg masses are placed on small squares of cheesecloth or muslin, depending on the size of the newly hatched insect, on the tightly stretched cheese cloth. Over each mass is placed a small glass dish, one-half to 1 inch in diameter, made of a ring of glass cemented with sodium silicate to a piece of thick, flat glass. The glass rings can be made by breaking off sections from a glass tube with a hot electric wire, special glass cutters, or by other means. The edges of the rings should be ground flat on emery paper.

Caging the egg masses individually eliminates the chance of newly hatched larvae devouring unhatched eggs.

Figure 6, C and D illustrate a cage that can be used for egg incubation and early larval development. When used as shown, the upper dish must always be well centered over the lower one, otherwise the glass and cloth will not fit together tightly, and the insects can escape. Instead of using one half of the petri dish as the liquid container, it is better to use a wider pan or dish slightly smaller in diameter than the embroidery hoop, as is shown in fig. 6E.

When a salt solution is used in the dish or pan, the container should

be coated on the inside with paraffin to prevent the salt creeping up the sides and coming in contact with the cloth cover.

In place of a petri dish for the upper part of the cage, a ring of celluloid or metal, and a glass plate can be substituted. A cage of this latter type can be made of any desired diameter and height to fit the requirement of the insect being reared. The edges of the ring should be ground so that they will fit tightly against a flat surface. If a seal tight enough to prevent escape of the larvae cannot be obtained in this way, then a pad made of a ring of cotton flannel should be fastened to the glass cover as shown in fig. 6E.

In some cases it is advantageous to use the arrangement shown in fig. 6F. The bottom of the cage is raised one-sixteenth of an inch or more above the table, depending on the number of insects and amount of plant material present. No solution is used below the cage. In it, thick types of leaves will remain in good condition for several days.

Figures 6, H and I show larger cages of this same type. Their use is described in the section on rearing methods. The celluloid may be cemented together with acetone. A half-inch strip of celluloid should be cemented around the outside of the base of these larger celluloid rings, in order that the lower embroidery hoop will fit tightly around the ring, and the upper embroidery hoop lid will fit on loosely. For some uses a screen ring up to several inches tall may be substituted for the celluloid ring.

Embroidery hoops have been obtained at local stores in sizes 3 to 7 inches in diameter. Metal hoops are preferable to the wooden type. Wooden hoops warp and the glued ends come apart in moist situations.

PARAFFINED SAND.—For certain purposes parafined sand is useful. It does not absorb moisture or become wet. When applied in a layer one-eighth to one-half inch thick over the wet sand or soil of pots or saucers of plants, it reduces surface evaporation of moisture, and growth of surface mold and damping-off fungi.

It is made as follows: Dry sand is wetted with a 5 to 7 per cent solution of paraffin in some paraffin solvent, as xylene, spread in a thin layer and allowed to dry, placed in an oven and heated to a temperature above the melting point of paraffin, and allowed to cool. Enough paraffin should be used to give the sand a slight waxy appearance, not so dry that it is dusty, or so waxy that it is sticky. The solvent should be free of residues of low volatility, as these will remain in the sand.

Insect rearing methods. MEXICAN BEAN BEETLE, *Epilachna corrupta.*—Continuous generations of this insect have been raised for a 10-month period in the indoor culture room on indoor-grown beans with no noticeable change in vigor, size or rate of reproduction or development.

The rearing methods followed are modifications of those used for the past several years at the federal Bean Beetle Laboratory, Columbus, Ohio. Two systems of providing adults for oviposition can be followed. In the fall a large number of adults can be allowed to go into normal hibernation in dry leaves on moist soil in a large outdoor cage. They should be provided with bean foliage as long as they will feed. They can be left in outdoor cages all winter, but if the weather is severe, the mortality may be high. A better practice is to collect the hibernated adults

in late fall, and place them in cold storage at 2 to 4° C in well-aerated containers in which the relative humidity is maintained near 100 percent. They may be placed in dry trays or among dry leaves, but must not be in contact with any wet or moldy material. Under these conditions, with well-fed beetles that have hibernated normally, the survival over a 9-month period should be 30 per cent or better.

The beetles may be removed from storage as needed. When removed the males should be separated and discarded to reduce the food consumption. The posterior margin of the posterior abdominal segment of the male has a distinct notch, while that of the female is continuous. At 25° C in the culture room they begin to lay in about 10 to 14 days. They continue to lay for two to four weeks, and then die.

A continuous supply of adults may be obtained by allowing successive generations of larvae to grow to maturity. In the culture room at 25° C new adults will begin to lay eggs when six to 10 days old, provided they have continuous access to fresh bean leaves. Starvation, for even a day, will greatly delay egg laying. To insure a continuous supply of eggs, groups of larvae should be grown to maturity every 10 to 14 days. The larvae must have continuous access to fresh bean leaves to develop into large vigorous adults. The new males and females should be kept together for the first week. Then the males may be separated and discarded.

The oviposition cage must be kept in a room, insectary or greenhouse where the temperature is uniform and near 25° C. If the beetles are subjected to successive periods of low temperature they will go into hibernation. In this study best results have been obtained by keeping the cage on the large table in the indoor culture room.

A cage of the type shown in fig. 3, B and C, 9 inches wide, 16 inches long, and 15 inches high, is satisfactory for oviposition. This size holds two 7½ inch saucers of bean plants.

One satisfactory procedure for obtaining and keeping the egg masses is as follows. Place one 7½ inch saucer containing 40 to 50 plants, with the first pair of leaves fully opened, in the cage. Place 20 to 25 females on the leaves. This number will eat about two-thirds of the leaf tissue in four to five days. If allowed to consume a greater portion of the leaves than this, they may eat the egg masses. It is very important in the case of this insect, and other plant-feeding beetles, that the number of adults to a cage be limited. If the number is such that most of the food material is eaten in one or two days, a large proportion of the eggs may be eaten. If all the food is consumed in one or two days, there likely will be periods when there is no food available, with a consequent large reduction in the number of eggs laid.

On the fourth or fifth day a fresh saucer of plants should be placed in in the cage along side the old one. By the following day most of the adults will have moved onto the fresh plants, and the old plants should be taken out. The leaves bearing eggs should be picked off and the tissue around each mass cut away.

The eggs in a given mass all hatch at about the same time. They stay in a group on the egg shells for about 12 to 18 hours and then scatter. They will devour other egg masses if present.

The egg masses obtained at the end of a five-day period are of different ages. They may be kept in a cage of the type shown in fig. 6, C, D and E, provided the cage is examined twice a day, and newly hatched masses removed. A more satisfactory system is to cage the masses individually until hatching, as shown in fig. 6, A and B. In either case, the eggs should be kept over a solution that maintains a relative humidity of about 75 per cent.

Another method that may be followed is to examine the plants daily, and remove the egg masses. The eggs may then be safely kept as a group in one cage, fig. 6, C, D and E, since they will hatch at about the same time. This system involves considerably more labor.

The larvae may be reared either on growing plants in screen cages or on picked leaves in cages of the type shown in fig. 6, C, D and E. If they are to be reared in screen cages, a newly hatched egg mass is placed on a leaf on a tray of growing plants. In the culture room this tray is kept on the table, connected to the watering system, and covered with a screen cage as shown in fig. 3, B and G. By the time the larvae have eaten sufficiently of the foliage that they tend to scatter, they cannot get through 16-mesh screen. When additional food is needed the tray is replaced with a tray of fresh plants. The old plants are cut off and laid over the top of the new plants for a day and then removed. This eliminates a hand transfer.

When fully grown the larvae pupate on the plants or side of the cage. The pupae may be removed and placed in an open petri dish or paraffined pill box in a screen cage with a tray of plants. This insures that the adults will have food available when they first emerge.

The larvae can be reared quite successfully through the first three instars in cages of the type shown in fig. 6, C, D and E, provided they are kept in a room where there are no sudden temperature changes. Under conditions of changing temperature, water condenses on the inside of the cage and makes its use impractical. Water is used in the lower container. This container should be 6 or 7 inches across. One newly hatched egg mass is placed on a leaf under a 3-inch cover on the cheesecloth. The next day another leaf is added. The third day two leaves are added. The fourth day several leaves are placed beside the pile of eaten leaves, and the 3-inch cover is replaced with one 6 inches in diameter. Later that same day the old leaves are taken out, after most of the larvae have moved onto the fresh ones. Thereafter once or twice a day fresh leaves are placed progressively in a circle around the edge of the dish, and the remnants of the old leaves removed.

Forty to 60 larvae, the number obtained from one egg mass, can be reared to the beginning of the fourth instar in a single cage by this method. If carried through the fourth instar this number has to be divided among several cages, because of the large amount of food that is consumed.

In the culture room at 25° C the length of the various stages is about as follows: egg six to seven days, larva 14 to 18 days, pupa five to seven days, and preoviposition period six to 10 days.

Various combinations and modifications of the above described meth-

ods for culturing Mexican bean can be worked out and adapted to the type of equipment available.

SQUASH LADYBIRD, *Epilachna borealis*.—This insect can be cultured by much the same methods as used for the bean beetle. Hubbard squash grown to the two-leaf stage in sand in saucers, (50 to 60 plants to a 7½-inch saucer) has been found to be the most satisfactory food plant. There are many varieties of the Hubbard squash. The Blue Hubbard was the first one tried and it proved very satisfactory, having straight, stocky stems and large leaves. The Chicago Warted Hubbard has also been grown. It does not have quite so stocky a stem as the Blue Hubbard but is still satisfactory.

There are probably other varieties of this and other types of winter squash that can be used. In any case, a seed that is large should be selected. Pumpkin, summer squash and other cucurbits grow too spindly under the light condition that exists in the greenhouse during the winter months and in the culture room.

Screen cages of the type used for bean beetle, only of such height that the plants just touch the glass top, are used for oviposition and larval rearing. For larvae the screen walls of the cage should be of such mesh that the newly hatched insects cannot escape, as they tend to disperse much more than do bean beetle larvae. Twenty-four-mesh screen, or coarser screen lined with cheesecloth, is satisfactory. They may be raised successfully on picked leaves as described for the bean beetle.

The egg-laying period of the adult is much longer than that of the bean beetle, lasting six to 10 weeks. It is especially important that the adults are not overcrowded in the oviposition cage. Ten females to a tray of 50 to 60 plants is a suitable number.

The chief difficulty in rearing this insect has been in obtaining a consistent satisfactory hatch of the eggs. Frequently only a few of the eggs in a mass will hatch. However, they lay so many eggs that a sufficient number of larvae usually can be obtained in spite of a low percentage hatch.

VARIEGATED CUTWORM, *Lycophotia margaritosa*.—This insect has been reared under cage conditions for six months, with a generation about every six weeks.

Leaves of members of the beet family are a favored food of the larvae. Leaves of mangels and perpetual spinach have been used for the most part. They can be raised successfully on crucifer leaves or on carrot roots supplemented with carrot tops, and probably other plants.

Gallon glass battery jars make satisfactory oviposition cages. Screen cages should not be used, as the adults will lay eggs on the screen, and they are difficult to remove.

An 7-inch embroidery hoop with cheesecloth stretched over it makes a handy cover for the battery jar. A small bottle of water containing three or four leaves of cabbage, rutabaga, Swiss chard or perpetual spinach should be placed in the jar. A loosely crumpled 6 by 18-inch strip of paper should be placed in the bottom of the jar around the water bottle, to provide a hiding place for the adults in the daytime. The adults should have daily access to a strip of cotton soaked in a 5 per cent honey solution.

Place 10 to 20 adults in this jar. This must be done in a transfer box, as the adults will fly actively when disturbed. A transfer box of the type described by Severin (1931) can be used. It consists of a large blackened box with black curtains on one end and white cloth or glass with a light shining through it at the other end. A transfer box of this type is useful for handling many kinds of insects.

The oviposition jar should be placed in a window, greenhouse or insectary. The temperature should be between 75 and 85° F. The jar must be shaded from direct sunlight or a fatal temperature will result. The moths begin to lay in about five days and will continue for seven to 10 days if provided fresh honey solution daily. The eggs are laid on the plant the cloth cover and the paper.

The incubation period is about five days, so that all eggs should be removed at least once every four days. The leaf, cloth or paper on which a mass is laid should be trimmed away. Groups of egg masses may be kept in cages of the types shown in fig 6, A–E, until nearly ready to hatch. The eggs gradually darken in color as they develop, getting quite dark just before hatching.

Newly hatched larvae of this species, and of many related species, tend to disperse soon after hatching. If they are not kept in a very tight cage at this stage most of them will be lost. At this stage it is necessary to confine them to a small space well filled with food material. Otherwise they tend to wander away from the food, and many become semistarved and develop poorly. The larvae of this and other related species excrete considerable frass, creating an undesirable condition in the usual battery jar and screen cages. To get around these difficulties the following system of rearing has been developed.

Cages of the type shown in fig. 6, E, F, H, I and J are used. The larvae are started in small cages, fig. 6F, 2 to 3 inches in diameter and five-eighths of an inch high, on 7-inch embroidery hoops. As they increase in size, rings of greater diameter are substituted. When they are about one-half inch long, a ring 1 inch tall and 7 inches in diameter is used, fig. 6H. As they become larger, and require more food, this ring is replaced with one 3 to 4 inches high, fig. 6I. If there are a large number of larvae present, a cloth cover is used as shown, and the cage is raised higher from the table top.

First a piece of cheesecloth is placed on the cloth bottom of the cage. On this a single layer of leaves is laid, and covered with a piece of cheese cloth slightly smaller than the area of the cage. On this more layers of leaves and cloth are added, the amount depending on the size and number of insects present. Then the insects are placed in the cage. When the food is consumed the entire mass of cloth, frass and larvae is gathered into a loose roll and removed. Layers of fresh food and cloth are added, and the roll of cloth, frass and larvae is replaced on top. After the larvae have moved down to the fresh food the waste material is removed. The excess moisture is absorbed by the cloth, keeping the food and insects in a clean condition.

This system of using alternate layers of leaves and cloth is followed throughout the development of the larvae. It works as successfully in the

small cages with newly hatched larvae as it does in the later instars. At the latter part of the last instar, the larvae are placed in the cage, shown in fig. 6J. This consists of an enameled pan 3 inches deep and 10 to 15 inches square, with a 1 to 1½-inch layer of moist sand in the bottom. The large larvae of this species cannot climb up the smooth sides of such a pan, and so no cover is necessary. A piece of waxed paper 2 inches smaller than the pan in length and width is laid on the sand and covered with two thicknesses of cheesecloth, layers of leaves and a layer of waxed paper. The larvae complete their feeding and pupate in the sand. As the food is consumed, the cloth is removed and replaced with fresh cloth and food.

The aeration in the cage should be varied with the number and size of larvae present. Aeration is controlled by the distance between the table top and bottom of the cage, the mesh of the cloth in the embroidery hoops, and the type of top used, whether cloth or glass. These factors should be adjusted so that the leaves will remain in good condition for two or three days, and the frass and cloth in the cage will not be too moist.

A cage of this type made with 7-inch embroidery hoops is large enough for 30 to 40 last-instar larvae.

If the larvae are supplied with plenty of fresh food and the waste material is removed regularly, very little difficulty with disease will be encountered. An occasional one may die, but it rarely spreads to any numbers.

FALL ARMYWORM, *Laphygma frugiperda*.—This insect has been reared for four months under cage conditions with a generation occurring every five weeks.

With some modification the methods described for rearing the variegated cutworm can be followed. Either screen or glass cages can be used for oviposition. The adults oviposit readily on corn plants 8 to 10 inches tall. A dense corn planting in a tray of sand is satisfactory. The cage should be only slightly taller than the plants. Ten to 20 adults are placed in the cage, along with a cotton strip soaked in 5 per cent honey solution. The cage should be kept in a situation where it is exposed to outdoor light, and where the temperature is between 75 and 85° F. Oviposition will begin in three to four days. Eggs are laid in masses on the leaves. They should be removed at least once every four days. Both corn and bean leaves have proved to be satisfactory food for the larvae.

If the larvae are reared by the method described for the variegated cutworm, a screen bottom is necessary in the embroidery hoop cage, or the larger larvae will cut through the cloth.

Another procedure for rearing the larvae is as follows. Allow the newly hatched larvae to develop for three days on tender corn leaves in a cage of one of the types shown in fig. 6, C, D, E and F. Then transfer them to a tray containing a dense planting of corn, 8 to 10 inches tall, or beans in a cage of the type shown in fig. 3, B and C. The plants should touch the glass top of the cage. The screen should be either of fine mesh or lined with cheesecloth. This food will carry larvae for several days. After they reach the last instar it is not advisable to place saucers of plants in

the cage, as the larvae will pupate in the sand and are difficult to remove because of the dense tangle of roots. Instead, a saucer containing a 1½-inch layer of moist sand is placed in the cage. The food material with the cut stems in a bottle of water is placed on the sand as needed. The larvae will pupate in the sand.

COLORADO POTATO BEETLE, *Leptinotarsa decemlineata*.—The culture of continuous generations of this insect has not proven practical. After a few generations the majority of the adults become dormant soon after they emerge from the pupal state, even though raised at a uniform temperature of 25° C. However, a continuous supply of adults for egg laying can be obtained by using beetles stored at low temperature.

In the late summer when the beetles normally go into hibernation, a large number should be collected in the field, caged with plenty of fresh foliage, and allowed to hibernate in shallow trays, damp soil or sand. These may then be recovered and stored as described for bean beetle adults. It is still better, where sufficient storage space is available, to store the beetles undisturbed in the trays of soil. If this is done some arrangement must be made to maintain the proper moisture content in the soil.

Another plan is to collect a large number in the field and allow them to hibernate normally in the soil beneath a cage. Then during the winter they can be dug out as needed.

Three months of cold storage are usually required to break the dormancy. To insure a supply of adults for egg laying during the late fall, a number of adults from the first generation in the spring should be made to go into dormancy, and then stored. This can be done with adults raised at any time of the year. To force them into dormancy they should be exposed to low temperatures a number of hours each day, gradually increasing the number of hours exposure, and lowering the temperature. During this process, they can be conveniently fed and handled in a cage of the type shown in fig. 6J. A screen cover should be provided for this cage.

When removed from storage and placed on fresh potato foliage, they will begin to oviposit in six to 10 days. Large, vigorous females will lay several hundred eggs over a period of two to four weeks. Better results are obtained when the adults are kept on plants under natural outdoor light rather than under artificial light. A screen cage of the type shown in fig. 3G is satisfactory. It should be of such a size that the plant touches the sides and top of the cage. Otherwise the beetles tend to stay on the screen at the top and not feed well.

The egg masses are kept in individual cages, fig. 6, A and B, until they hatch. The larvae may be raised conveniently according to the method described for the early stages of the variegated cutworm, using the cages shown in fig. 6, F and G. They are started in a celluloid ring one-half inch high and 2 to 3 inches in diameter. As they grow a larger ring is used. Finally the ring is discarded, and the glass plate is laid on the rim of the embroidery hoop, fig. 6G. Fifty larvae can be reared successfully in one 7-inch cage.

It is not necessary to use cloth between layers of leaves. Leaves are

picked from the stem and placed on the bottom of the cage one layer deep. If no stems are present there will be practically no uneaten plant material left. Considerable frass residue accumulates on the cheesecloth bottom of the cage. However, it dries out quickly when the aeration is properly adjusted, and need not be removed.

When the larvae reach the latter part of the last instar they should be transferred to a cage of the type shown in fig. 6J, containing a 2 to 3-inch layer of moist sand or preferably a sandy loam. A flower pot can be used in place of a pan. If the pupae are removed from the soil a high mortality may result. It is best to leave them undisturbed in the soil, and collect the adults later as they appear.

If there is a shortage of potato foliage the larvae can be raised on slices of potato tuber, providing they are given a few green leaves every two or three days. Adults can be kept alive for several weeks on potato tuber, but will not lay eggs.

It is necessary to make special provision for seed potatoes for the late summer, fall and winter months. By spring a supply of the previous season's crop of seed must be placed in cold storage. The optimum storage conditions are 36 to 37° F and 90 to 95 per cent relative humidity. If the temperature is lower the sprouts may be killed. If it is higher the potatoes will not keep. If the humidity is too low the tubers will dry out.

These tubers are brought out and planted in pots of soil as needed.

Some of the published methods described for breaking the dormancy of new potatoes were tried. They shortened the dormant period, but not enough to make this plan practical.

Summary.—A study was made on methods and equipment for rearing test insects and food plants under controlled and standardized conditions that can be maintained throughout the year. An efficient method for growing certain types of plants in trays under controlled conditions, an automatic method for watering these plants, methods for rearing several species of test insects, and several new types of insect cages were developed.—1-15-37.

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Chrysanthemum, aster, dahlia and gladiolus were eliminated from the restrictions of the California quarantine relating to the European corn borer, and Delaware was added to the infested area, under a revision of Quarantine Proclamation No. 15, issued December 18, 1936.

Sweetpotato weevil regulations of Arkansas and Mississippi were revised in December 1936. The former state requires, as to shipments from all states, certification that the tubers were grown in a weevil-free county, except that between July 1 and January 1 of each year, inspection of the tubers may be substituted therefor. A permit is required for shipping sweetpotato plants into Arkansas. The Mississippi regulation was extended to apply to three Georgia counties not previously affected.

Studies on Calcium Arsenate[1]

HAROLD WATERS and EUGENE WITMAN,[2] *The Sherwin-Williams Company Research Project,*[3] *The Ohio State University, Columbus*

For many years it has been noted by growers and research men that the injury to plants resulting from the use of calcium arsenate was rather erratic. It appeared that some commercial brands were more toxic to plants than others, and that different batches of the same brand varied in their effect on foliage. In order to get definite information on this point, Howard & Fletcher (1933) compared the plant toxicity of 16 brands to bean foliage in field tests at Columbus, Ohio, over a period of several years. They found very definite differences in the relative safeness of the various brands.

The samples tested by Howard & Fletcher (1933) were analysed by the Insecticide Division of the Bureau of Chemistry and Soils, (Smith & Murray 1935). Results for total CaO and As_2O_5 or for water-soluble arsenic as determined by the A.O.A.C. method were not correlated with injury to bean foliage. However Pearce, Norton & Chapman (1935) demonstrated that the percentages of water-soluble arsenic can be correlated with injury to foliage if the free lime in the sample is removed by carbonation before the water-soluble arsenic is determined. By this modified method, which the present writers have used, Pearce, Norton & Chapman (1935), found that some brands contained much more water-soluble arsenic than others. They concluded that arsenicals containing .75 per cent water-soluble As_2O_5 or less are safe on most foliage. The value of 2.5 per cent water-soluble As_2O_5 was set as the upper limit for intermediate products. A percentage above this was considered unsafe.

Howard & Davidson (1935) showed by field tests on bean foliage that autoclaving (heating under steam pressure for several hours) an unsafe calcium arsenate renders it safe.[4] Chemists working on this could not explain what physical or chemical changes occurred. Also the reasons for the variations in commercial lots were not understood.

Factors involved in formation of safe calcium arsenate.—In April 1936 the authors began a study of the relations between conditions of preparation and safeness of calcium arsenate, in an attempt to work out a satisfactory low-cost method for producing safe material on a commercial scale.

In the commercial process of making calcium arsenate, calcium oxide is slaked with water in large vats. Then, while the hot suspension is agitated, arsenic acid is sprayed into it and calcium arsenates are formed.

Laboratory studies soon indicated that the degree of agitation of the

[1] The term calcium arsenate is used in this paper to denote the complexes of calcium oxide and arsenic oxide that may occur in a commercial product.

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[3] Early publication of this paper has been secured by payment of the printing charge.

[4] The term safe is used to denote a relative difference in the toxicity of a calcium arsenate to plants. It does not imply that a material can be applied to all field plants under all climatic conditions without injury resulting.

lime suspension during the time the arsenic acid is being added has a marked effect on the toxicity to plants of the resulting calcium arsenate. Material prepared in a beaker with rapid agitation had a water-soluble arsenic content of .5 per cent As_2O_5, and was as safe on bean foliage as autoclaved calcium arsenate. Material prepared under identical conditions, except that the agitator was operated slowly, had a water-soluble arsenic content of 3 to 4 per cent and was quite toxic to bean foliage.

The detailed studies of Pearce & Norton (1936) showed that the composition of the calcium arsenate precipitated depends on the acidity at

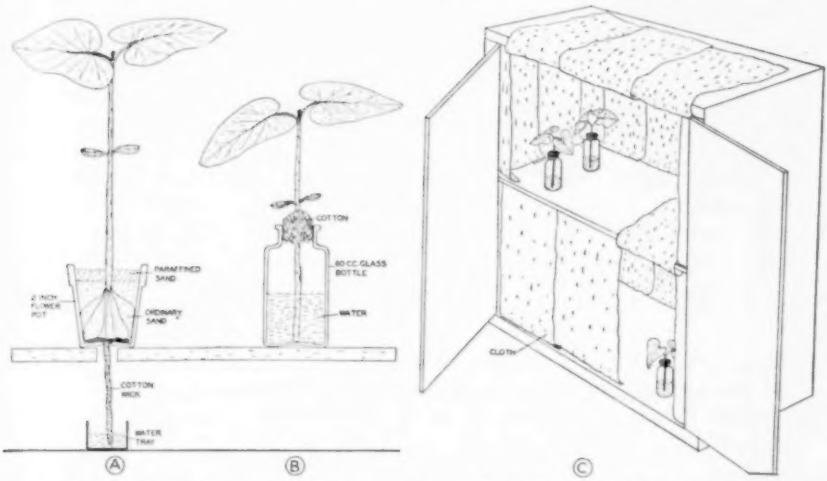

Fig. 1.—A, Bean plant grown individually in 2-inch flower pot for chemical injury test. B, Bean plant in bottle of water for chemical injury test. C, Humid cabinet used to keep leaves wet during chemical injury test.

the point of reaction of the acid and calcium hydroxide, the more basic conditions favoring the formation of arsenates with low water solubility. As the acid drop falls in the suspension of hydrated lime it instantly neutralizes the dissolved calcium hydroxide and lowers the pH in the immediate vicinity. During the time the lowered pH exists, some of the more soluble calcium arsenates may be formed. Once formed, they do not readily change to more basic insoluble arsenates even under the optimum conditions for the formation of the latter, and are quite certain to carry over into the final commercial product.

When the suspension of hydrated lime is in a violent state of agitation during the addition of the acid, the drops of acid are immediately dispersed throughout a comparatively large volume of lime suspension, largely eliminating local changes in pH.

Factors other than agitation are also very important in the formation of the safe type of calcium arsenate. It has long been known by manufacturers that a more desirable product is obtained when the reaction takes place at a high temperature. Pearce & Norton (1936) demonstrated

by chemical tests that high temperature favors the formation of the basic forms of calcium arsenate. Laboratory tests by the authors verified this, and demonstrated that 75 to 100° C is the optimum temperature range for formation of a safe type of calcium arsenate.

The rate of addition of the acid is important. Under the conditions of commercial production, where a rather concentrated lime suspension is used, the acid should be added over a period of two hours. Reduction of

Table 1.—Summary of mortality of insects in laboratory cage tests.

Units of Dosage*	No. Insects for Each Material	Percentage Dead by Days							
		Ordinary† Calcium Arsenate				Safe‡ Calcium Arsenate			
		1	*2*	*3*	*total*	*1*	*2*	*3*	*total*
	Mexican Bean Beetle, Epilachna corrupta—*Fourth-instar Larvae*								
½	8	0	0	0	0	12	0	0	12
1	14	7	14	7	28	14	7	7	28
2	8	12	0	0	12	24	0	0	24
4	19	40	0	0	40	72	5	0	77
8	14	70	14	0	84	70	0	0	70
	Squash Ladybird Beetle, Epilachna borealis—*Fourth-instar Larvae*								
½	8			0	0			37	37
1	8			37	37			50	50
2	8			50	50			50	50
4	8			63	63			88	88
8	8			100	100			100	100
	Variegated Cutworm, Lycophotia margaritosa—*Fifth-instar Larvae*								
1	50	2	2	0	4	2	4	0	6
4	50	34	30	22	96	40	24	14	86
	Variegated Cutworm, Lycophotia margaritosa—*Fourth-instar Larvae*								
1	20	5	10	10	25	5	0	0	5
4	20	20	55	15	90	40	25	25	90
	Fall Armyworm, Laphygma frugiperda—*Last-instar Larvae*								
1	14	35	7	0	42	35	7	0	42
4	14	100	0	0	100	72	28	0	100
	Fall Webworm, Hyphantria cunea—*Last-instar Larvae*								
1	12	0	16	24	40	0	8	8	16
4	12	0	66	24	90	0	40	80	80

* One unit of dosage indicates an application of .042 milligram of calcium arsenate per square centimeter of leaf surface. The insects were caged with sprayed leaves for the entire three-day period.
† Ordinary calcium arsenate = 3.5 per cent water-soluble arsenic.
‡ Safe calcium arsenate = 1 per cent water-soluble arsenic.

this time increases the percentage of water-soluble arsenic in the product. The use of diluted rather than concentrated arsenic acid favors the formation of the safe type of calcium arsenate. The slaking period of the lime is another important factor. The lime should be allowed to slake for several hours before the acid is added. The production of a safe calcium arsenate requires the use of a good grade of chemicals. The lime must be fresh, with a minimum of carbonation. The acid must be free from As_2O_3. These principles have been applied to large commercial batches and found to hold true.

Calcium arsenate with a water-soluble arsenic content as low as .4 per cent As_2O_5 has been made. One per cent material proved safe on bean foliage in laboratory tests.

Application of the above-described principles results also in a distinct

improvement in the physical properties of the calcium arsenate. The material is more finely divided and has greater adhesive and covering properties. Pearce & Norton (1936) report that the more basic forms of calcium arsenate are amorphous in character, whereas the more acid forms are crystalline. Slaking the lime for several hours previous to the addition of the acid results in a more finely divided condition of the lime particles, and this condition carries over in the final product.

The variations in the toxicity to plants of commercial brands of calcium arsenate probably can be explained on the basis of the above-described factors.

Rapid laboratory method for determining toxicity of calcium arsenate to plants.—A rapid laboratory method of testing arsenical injury to plants was needed because field tests are slow and limited to certain seasons of the year, and the results are dependent on weather conditions. Such a method was developed and used only as a control guide during developmental work.

Cranberry bean plants raised under the controlled indoor conditions described by Waters (1937) were found to make good test plants. The foliage is much more succulent and sensitive to arsenical injury than that of field plants. The same type of plant can be grown at any time of the year. Other plants that can be grown under these conditions and used for tests are peanut, squash, corn and peas. However, in the work on calcium arsenate only bean plants were used.

Two systems of handling the plants have been tried. (1) The plants may be raised singly in 2-inch paraffined flower pots filled with sand and watered automatically with a wick. The plants are used with the root system undisturbed, fig. 1A. (2) A second system consists of raising about 25 plants in a flower pot saucer (7½ inches across the top). When ready for use the stems are cut and placed in a bottle of water, fig. 1B. This system involves less labor where large numbers of plants are required. The two systems give comparable results in tests for plant injury.

Under the culture room conditions described, the first pair of leaves of the bean plant will reach full size in 10 to 12 days after planting. They retain the bright green color for eight to 10 days and then begin to turn yellow and die. The best period for use in chemical injury tests is during the first seven days after the first pair of leaves have reached full size. The leaves become increasingly susceptible to arsenical injury with age, being most susceptible when yellowing sets in. The central shoot that bears the trifoliate leaves should be kept cut back to stop its development.

The general principle involved in this rapid laboratory test is the same as that described by McGovran & Farrar (1936). Plant injury is accentuated by keeping the leaf wet for a period after the spray is applied, by placing the plants in a chamber having a high humidity. The extent of leaf injury that results after different intervals of exposure to the wet condition is taken as a measure of the toxicity of the material being tested.

It was found that the method of applying the chemical to the leaf has a decided effect on the results obtained. If the material is applied

with an atomizer type of spray gun, severe plant injury will often occur with the safest forms of calcium arsenate. Applying the spray with a camel's-hair brush gives the same type of results. The factors involved here have not been determined. To eliminate this difficulty the following method was used. The leaves were first dampened with water mist from an atomizer. Then the chemical to be tested was dusted upon the wet surface from a small cloth bag. The leaf was then further wetted with mist from an atomizer till it held as much water as possible without a run-off. The plants were then placed in the humid cabinet.

The upper surface of the bean leaf is much less sensitive than the lower surface. Results are obtained more rapidly if the lower surface is used.

Another satisfactory and still more rapid method is to dip the leaves in a suspension of the material, made up to a concentration necessary to give the desired deposit. The plant should be lowered into, and removed from, the suspension very slowly. If the leaves are moved about rapidly or rubbed against the sides of the container severe injury often results with safe materials.

A humid chamber of the type shown in fig. 1C was used to keep the leaves wet. The cloth lining was thoroughly soaked with water at the start of the test and resoaked once a day. If only a few plants are included in a test or if a humid cabinet of some type is not available, a 50-pound lard can coated on the inside with a thin layer of water mist from an atomizer can be used. It is inverted over the plants, and the crack between the table top and can is sealed by wrapping a long strip of wet cloth about the can.

Glass bell jars are not suitable as humid chambers. Unless used in a dark cabinet, the leaves will be dried by absorbed radiant heat, even though the relative humidity in the jar is 100 per cent.

Injury usually appears as an outright killing of the leaf. The leaves look fresh and green when removed from the cabinet, but the dead areas dry out in a few hours. The live areas remain green for several days, and the percentage injury does not change while the material is present on the leaf in a dry condition. An occasional plant shows a general slow progressive wilting type of injury, which occurs most frequently when the temperature in the culture room exceeds 25° C during the test.

In general the results obtained in these tests are as follows. Unsafe materials applied to the upper surface only will cause 100 per cent injury when the leaves are kept wet for six to eight hours. On the lower surface one to two hours are required, and by the dip method less than one hour is necessary. Safe materials on the upper surface cause but little injury in a three-day wet period. On the lower surface very slight injury occurrs in one day and only moderate injury in two days. By the dip method only slight injury occurs in 12 hours, and moderate injury in 24 hours.

On the basis of these tests the factory lots of calcium arsenate made by rapid agitation and having a water-soluble arsenic of 1 per cent As_2O_5 are of the safe type.

Comparative toxicity to insects of safe and unsafe calcium arsenates.—Several cage tests on the comparative effectiveness of the two materials

have been made. By means of specially designed spray equipment, to be described in a subsequent paper, the material was applied in controlled quantities of poison per square centimeter of leaf surface. The maximum variation in distribution was not over 10 per cent. The use of this system eliminates one of the major variables of this type of test.

The insects used were parasite free and raised at a constant temperature of 25° C. They were allowed free access to sprayed leaves in small screen cages. The number of dead were recorded at daily intervals for three or more days. A range of concentrations per square centimeter was used, varying from one that caused little mortality to one that caused high mortality. The tests were conducted in a room where the temperature was maintained at 25° C and the relative humidity at 55 to 60 per cent.

In the tests to date 24 to 140 insects of each species have been used. The numbers involved are too small for drawing final conclusions but the results are suggestive.

The tests on Mexican bean beetle do not indicate any marked difference in toxicity. This checks with the field tests of Howard & Fletcher (1933), who found the safe materials in general were fully as toxic to bean beetles as the unsafe type. Tests on the squash ladybird showed no marked difference in toxicity. Tests on variegated cutworm did not indicate any marked difference in toxicity. In the tests on the fall armyworm the mortality rate was about the same, but it was evident that the area of sprayed leaf eaten by the larvae was about one-half greater in the case of the safe material.

In the test on the fall webworm the same indication was noted, only it was more marked, the larva eating about twice the leaf area in the case of the safe material.

On the basis of the data at hand it seems that for certain insect species the safening of calcium arsenate makes no change in its toxicity, whereas for other insect species it does lessen its toxicity. If further tests confirm this, then it will be necessary to determine which insect species it will successfully control and make recommendations accordingly.

In view of the known differences in toxicity to plants and the indications of differences in toxicity to insects of the safe and unsafe types of calcium arsenate, entomologists, in reporting any work with calcium arsenate, should include as much chemical and physical data as possible about the particular materials used.

Summary.—The factors involved in the formation of the so-called safe type of calcium arsenate were determined, and a method of making safe material on a commercial scale was developed. A rapid laboratory test for arsenical injury to plants was developed and used extensively. The comparative toxicity of the safe and ordinary types of calcium arsenate to several insect species was studied.—1-15-37.

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Scientific Notes

Sugar Beet Leafhopper, *Eutettix tenellus* Baker, Appears in Illinois.—Although the sugar beet has been grown on a commercial scale in the states east of the Mississippi river for many years, the sugar beet leafhopper has never been found feeding upon that crop. There is only one record which has previously been reported for this pest in the eastern United States. This was found in Florida by DeLong (1925. Jour. Econ. Ent. **18**(4):637–8) at Miami and collected from sea purslane, *Sesuvium portucastrum* L., a native food plant and abundant upon the sandy upper beach of the Atlantic coast. The finding of this pest in the east under Florida conditions caused no alarm because it presented no immediate or possible danger. On October 6, 1936, many specimens of *E. tenellus* were collected from horse-radish at Collinsville, Ill. This latter finding may be of some consequence because of its proximity to the eastern sugar beet area. Three years of intensive leafhopper collecting in many localities over all parts of the state by members of the Illinois State Natural History Survey staff, preparatory to a publication on the leafhoppers of Illinois, has failed to reveal this insect anywhere else in the state.

The leafhoppers were taken in association with an outbreak of a disease on horse-radish (1936. Plant Disease Reporter **20**:288) which is apparently identical with the curlytop disease on horse-radish as described by Severin (1929. Hilgardia **3**:595–629). A collection of leafhoppers from the diseased horse-radish shows a few specimens of *Aceratogallia sanguinolenta* (Prov.), a few specimens of *Cicadula divisa* Uhler and a large proportion of *Eutettix tenellus*. Since the latter transmits curlytop in the west there is a possibility that in Collinsville, Ill., we have an occurrence of both the disease and its vector. This, of course, will need to be substantiated by experimental data.

D. M. DeLong, *Ohio State University* and K. J. Kadow, *University of Illinois*.—12-20-36.

Unusual Abundance of *Thyanata custator* (Fabr.) in South Dakota.—During the night of October 5, 1936, an immense swarm of *Thyanata custator* (Fabr.) flew into the city of Sioux Falls, S. D. While this species of Pentatomidae is generally distributed over South Dakota, it has never been known to cause any serious damage to crops in this state and rarely has it caused serious damage to crops in other states. During the evening on which the invasion of Sioux Falls took place and during the succeeding few days, millions of the bugs swarmed about the lights of the city, invaded stores, hotels, bakeries, homes, apartment buildings, etc.

H. C. Severin, *South Dakota State College, Brookings*.—11-19-36.

Pyrethrins in Fresh Pyrethrum Flowers.—In a recent paper entitled "Constituents of Pyrethrum Flowers. III. The Pyrethrin Content of Fresh Flowers," by Acree, Schaffer & Haller (1936. Jour. Econ. Ent. **29**(3):601–5), it was shown that the active insecticidal principles of pyrethrum flowers, pyrethrins I and II, are present as such in the

fresh, undried flowers. The studies reported in this paper were undertaken after a search of the literature, in which we were guided by the monograph on pyrethrum flowers by Gnadinger, had failed to reveal any similar studies.

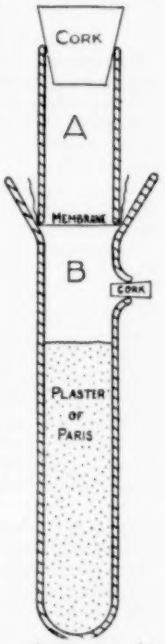
Our attention now has been called by J. Ripert to an article published by him several years ago (1932. Ann. Falsif. **25**:395–409.) in which studies are reported on this subject. Although this article is cited in the references listed in the monograph by Gnadinger, the studies on the fresh flowers probably were overlooked by him because of the title chosen by Ripert for his paper, *viz.*, "Review of the Pyrethrum Problem."

Comparison of the results reported by Ripert with those obtained by us shows them to be in substantial agreement.

H. L. Haller, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*—12-4-36.

Improved Device for Artificial Feeding of Aphids.[1]—In the course of experiments involving artificial feeding of aphids, the devices described by Carter (1927, 1928), Hamilton (1930) and Severin & Freitag (1933) were given consideration. All of these proved unsatisfactory in one or more respects; either the area of exposed membrane was too great, resulting in sagging or breaking, or there was no provision for readily introducing more insects without losing those already present. Also, the described types of apparatus were designed chiefly for leafhoppers, which will feed readily on the upper surface of a feeding area. The habits of most aphids require that some provision be made for feeding on the lower surface of the feeding area.

Accordingly an apparatus was designed which consisted of glass cages constructed from test tubes. The mouth of a standard, soft-glass test tube (not Pyrex) was given a more extensive flare by heating it, and turning and pressing it while hot against a tapered carbon rod of greater diameter than the desired flare. (Such a carbon rod was made by filing to a blunt point the core of a discarded dry cell.) A glass cylinder A was made by cutting the closed end from a test tube. The resulting cylinder was thus of the same diameter as the lower chamber B. To prevent the escape of young aphids it was essential that the upper cylinder fit closely on the flared top of the lower tube. When a membrane ("fish-skin," "gold-beaters' skin," or "capping skin") was fastened over one end of the glass cylinder A, the resulting liquid-holder could be supported in the upper flare of the test tube chamber B.



Apparatus devised for experiments involving artificial feeding of aphids.

To permit placing aphids in chamber B without removing the upper cylinder A, an aperture was made in the side of the chamber. This was accomplished by touching the side of the test tube chamber, when hot, with the warm tip of a glass rod. A nipple was then drawn out, the tip broken off, and the edges smoothed. A small rubber stopper was cut to fit the aperture.

The lower two-thirds of chamber B was filled with plaster-of-Paris. This filling lessened the vertical distance which the aphids must travel to reach the membrane, and, when moistened with water, kept up the humidity in the chamber. In addition, short strips of rough paper were placed vertically in the chamber to aid the aphids in reaching the membrane.

When used singly the cages were held by ordinary burette clamps. When a series of cages was required, the lower tubes were supported in holes in a wooden rack while the upper cylinders were held firmly in place by burette clamps.

For the feeding of aphids, the apparatus described above presents several advantages over previously described devices:

1. The exposed membrane area is not excessive, and the feeding liquid does not break through the punctures.

2. The feeding area constitutes the entire upper limit of the cage space B where aphids naturally congregate and can find food readily after random climbing activity.

[1] Paper 1469 of the scientific journal series of the Minnesota Agricultural Experiment Station.

3. Insects may be introduced without losing those already present.
4. Observation of the insects is possible by focusing a dissection binocular on the lower surface of the membrane.
5. The moist plaster-of-Paris maintains conditions of high humidity necessary for aphids in the chamber where aphids are confined.

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D. J. Pletsch, *University of Minnesota, Minneapolis.*—12-18-36.

Dichloroethyl Ether for Wireworm Control.—Dichloroethyl ether proved to be toxic to wireworms, *Limonius* (*Pheletes*) *californicus Mann.*, in a series of preliminary experiments carried on during the winter of 1935–36. The form used was beta–beta–dichloroethyl ether ($ClCH_2CH_2OCH_2CH_2Cl$), manufactured for commercial and technical use, such as a solvent, an extractant, or an intermediate chemical for the production of other chemicals. Small screen cages, each with five live wireworms, were placed at depths of 4, 8 and 12 inches, in pots containing 1 cubic foot of soil. Dichloroethyl ether, at concentrations of 1, 3, 5 and 7 cc. to 1 gallon of water, was applied to the surface of the soil in the pots, at the rate of 1 gallon per pot.

The percentages of wireworms killed in these experiments are shown in table 1.

Table 1.—Percentages of wireworms killed with different concentrations of dichloroethyl ether at different depths in the soil. Laboratory experiments.

Dichloroethyl Ether Cc. per Gallon of water	Per Cent of Wireworms Killed at Depths of 4 inches	8 inches	12 inches
1	60.	60.	13.3
3	66.6	73.3	6.6
5	100	100	33.3
7	100	100	30
Water alone	0	0	0

The fact that the soil was more nearly saturated at the 4 and 8-inch levels than at the 12-inch depth apparently accounts for the better killing at the shallower levels.

In view of the promising results obtained in pots during the winter, when the wireworms were relatively inactive, further experiments in infested fields were tried in the spring, after the wireworms had become active. Since an excess of dichloroethyl ether solution would be required to flood the soil with sufficient liquid to penetrate deep enough to kill wireworms, it was necessary to devise some method of application requiring less material. This was accomplished by applying dichloroethyl ether solution to baited rows to which wireworms had previously been attracted. It has been demonstrated (Campbell 1926) that wireworms can be concentrated into bait rows.

An applicator was constructed by attaching a 5-gallon can to a hand planter, with a quarter-inch tube running from the can down into a shank of the planter shoe. At concentrations of 5, 20, 40 and 80 cc. per gallon of water (with more than 30 cc. some was insoluble and the excess had to be emulsified) the dichloroethyl ether solution was drilled into bean rows at a depth of 2 to 3 inches and at the rate of 1 quart per 100 feet of row. This proved too light an application, since much of the soil around the infested beans was not thoroughly wetted, and a maximum of only 55 per cent of the wireworms was killed.

A 1-inch tube was substituted, which permitted applying 1 gallon to 15 feet of row. At a concentration of 5 cc. of dichloroethyl ether per gallon, 96.6 per cent control of the wireworms was obtained, and at 20 cc. 100 per cent kill resulted, both when the solution

was drilled into the soil and when it was poured onto the surface of the row. The soil in this field was a heavy loam.

The final experiment was made in a field of sandy loam, where the wireworm population ranged from .5 to 2.5 per foot of row. Both the concentration and the quantity of liquid applied varied. The results are given in table 2.

Table 2.—Percentages of wireworms killed with different concentrations of dichloroethyl ether and different quantities of liquid, when applied in a field of sandy loam.

Dichloroethyl Ether Cc. per Gallon of water	Method of Application	Solution Used per 100 Feet of Row Gallons	Per Cent of Wireworms Killed
2	Drilled in	10	17.8
	On Surface	7	6.4
5	Drilled in	8	94.7
	On Surface	6	52
10	Drilled in	1	68.7
	On Surface	5	100
Water	Drilled in	6	0
	Untreated		0

These experiments show that dichloroethyl ether in dilute solutions, applied to the soil under the conditions described in these experiments, will kill wireworms.

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Roy E. Campbell and M. W. Stone, *U. S. Department of Agriculture Bureau of Entomology and Plant Quarantine, Alhambra, Calif.*—11-9-36.

Dichloroethyl Ether as a Control for Sod Webworms in Lawns.—During the summer of 1936 damage to blue-grass lawns by the sod webworm, *Crambus* sp., was so severe in Los Angeles county that many new lawns were completely destroyed. Populations as high as 25 worms per square foot were common. The effectiveness of dilute solutions of dichloroethyl ether on wireworms led to several trials of this material against webworms.

A concentration of 5 cc. of dichloroethyl ether per gallon of water was applied to 50 square yards of turf with a sprinkling can at the rate of 1 gallon per square yard. Examination of eight one-quarter square-foot plots 24 hours after treatment showed a kill of 65 per cent of the sod webworms, which were originally present at the rate of about 25 per square foot. In another plot consisting of 44 square yards, infested at the rate of 21 webworms of all sizes per square foot, a concentration of 10 cc. of dichloroethyl ether per gallon of water was applied at the rate of 1 gallon per square yard. Siftings made two days later in six one-quarter square-foot plots disclosed only dead larvae, although several pupae were found apparently unaffected. Since the dead larvae were distintegrated, it was impossible to count them. The same treatment was applied to a larger lawn, and a 100 per cent kill of sod webworms again resulted.

Frequent inspections during the month after treatment showed no perceptible injury to the grass in either of the lawns treated. The cost of treating lawns with dichloroethyl ether at the 10 cc. concentration amounts to about half a cent per square yard for material alone.

Other materials tested, but which were found ineffective or partially so, were as follows: Pyrethrum extract (1 oz. to 4 gals. of water) applied at the rate of 1 gallon per square yard brought many of the webworms (24 per square foot) to the surface, but only a few (8.7 per cent) of these were killed. An examination after carbon disulfide emulsion (4½ oz. in 10 gals. of water with soap) had been applied at the rate of 1 gallon per square yard showed 13 live and 13 dead worms. Kerosene emulsion, 1:50 (1 lb. soap, 1 gal. boiling water, one-half gal. kerosene), used at the rate of 1 gallon per square yard, was ineffective, there being 15 live and no dead worms after the treatment.

M. W. Stone and J. C. Elmore, *U. S. Department of Agriculture Bureau of Entomology and Plant Quarantine, Alhambra, Calif.*—12-10-36.

Preliminary Toxicity Tests with Horseflies.[1]—Apparently very little is known concerning the toxicity of the more common fly-spray materials to horseflies. For this reason, a few tests were conducted during the summer of 1934. Flies captured in the field were brought into the laboratory in screen-wire cages and treated in a Peet-Grady chamber. At the end of 12 hours all flies, both sprayed and unsprayed, were dead, presumably from the effect of being confined as described during the interval of transportation to the laboratory and in part to injuries received in their frantic efforts to escape from the spray chamber.

In 1935, the flies were collected from a single cow by the use of a glass tube having a Cellophane funnel in the open end which prevented escape and also made it unnecessary

Preliminary Toxicity Tests with Horseflies

Material	No. Flies	Down in 10 Minutes		Died in 12 Hours		Died in 12–24 Hours		Total Dead in 24 Hours	
		No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Check (unsprayed)	270*			9	3.3	15	5.6	24	8.9
Deo-Base	223†	145	65.	135	60.5	21	9.4	156	69.9
5% 20:1 pyrethrum–*Deo-Base* Extract; 95% No. S-41 base oil, 40–45 seconds viscosity	285‡	283	99.3	285	100.			285	100.

* 7 replications averaging 38.5 flies each. † 7 replications averaging 31.8 flies each.
‡ 8 replications averaging 35.6 flies each.

actually to touch the flies. Since it was believed that a greater part of the mortality noted in the tests of the previous year was more or less self-inflicted, an effort was made to eliminate this possibility. Cages 8 by 8 by 9 inches and covered with black cloth, with from 30 to 40 flies per cage, seemed to solve the problem of transporting the flies to the laboratory without injury. The flies were treated on the same afternoon they were captured.

Removing the source of light from the spray chamber would have prevented the flies from flying blindly into the glass doors but was not feasible, since light was necessary both at the time when the flies were released and again when they were collected after treatment. It was decided, therefore, to clip the wings of the flies before releasing them in the spray chamber. This was accomplished by holding the fly gently between the thumb and forefinger and clipping the wing tips with dissecting scissors. The cut was made from approximately the fifth posterior cell diagonally across the wing to a point just beyond the distal end of the subcostal cell. Removing this portion of the wing did not seem to cause any apparent harm. The technic followed in spraying was identical with that of Pearson (1935. Del. Ag. Exp. Sta. Bul. 196). The fact that it is not practicable to cage large numbers of horseflies together accounts for the comparatively small number in each replication. The results of these tests are shown in the accompanying table.

In the unsprayed check 8.9 per cent were dead in 24 hours. With *Deo-Base* alone, the total dead in the same period was 69.9 per cent, while all of the flies were killed with a 5 per cent 20:1 pyrethrum–*Deo-Base* Extract in 95 per cent No. S-41 base oil. In all of the tests the number of flies down in 10 minutes was nearly equal to the total dead in 24 hours. Of the species used in these tests, 90.2 per cent were *Tabanus nigrovittatus* Macq.; 7.7 per cent *T. lineola* Fab.; 1.3 per cent *T. atratus* Fab.; and .8 per cent *T. daeckei* Hine. Data on the toxicity of the same pyrethrum spray to house flies, obtained previously by Pearson in the same chamber, show that while 75 per cent were down in 10 minutes only 12.3 per cent were dead at the end of the 24 hour-period. It would seem from these preliminary tests that the tolerance of horseflies is considerably less than that of a healthy strain of laboratory-bred house flies.

It is admitted that "wild flies" of unknown age are not ideal insects upon which to make toxicity tests. However, any tests made with the Tabanidae are likely to be of this nature, since the large-scale laboratory production of horseflies such as now obtains with house flies is probably impossible.

Donald MacCreary and A. M. Pearson, *Delaware Agricultural Experiment Station, Newark.*—12-23-36.

[1] The information given in this note is in connection with a project of the Delaware Agricultural Experiment Station and is published by permission of the Director.

High Infestation of *Prionus laticollis* Drury in Ohio.—This giant cerambicid has been reported from many localities, but usually when found in apple orchards the numbers of larvae are few, averaging rarely more than one or two per tree. In early November 1936, apple trees on an estate north of Youngstown, Ohio, were examined following a request for aid to control "borers." Numerous old apple trees which were growing in an extensive lawn were found to be very heavily infested by this species. One large tree had all roots extending as far as 5 and 6 feet from the trunk and as deep as 2 feet honeycombed with the tunnels of the larvae. The foreman who supervised digging up the tree stated that there were at least 200 borers present, and, while this estimate was probably large, the condition of the roots indicated very high numbers, considering the species involved.

C. R. CUTRIGHT, *Ohio Agricultural Experiment Station, Wooster.*—11-27-36.

Flight and Movement of Peach Borer Moths.—The following observations on the flight and movement of moths of the peach borer, *Conopia exitiosa* Say, have been made in the course of studies of that insect at Fort Valley, Ga. The flight of female moths has been observed by following them from point to point; that of the male moths, by means of their attraction to females.

Although the female moths are strong fliers, they seem to have a tendency to remain fairly close to the tree from which they emerged. They usually mate close to the point of emergence, after which most of the eggs are deposited on that tree and on those nearby. One female was observed to oviposit continuously for 1 hour 33 minutes on the tree on which the individual had mated just before this oviposition record was made. Three hundred fifty-seven yards is the greatest distance that a female has been observed to fly in one day from the tree on which she started to oviposit, and in this case the female ended her flight only 215 yards from the starting point.

The female moths have a definite tendency to fly in circles, and they often return to the starting point. Moths released in open fields make circular flights, apparently with no destination in view. On several occasions when this study was being conducted, the female moth was lost sight of in flight, in one case at two different points, both of which were 85 yards from the starting place, but was recovered by merely waiting at the exact spot of release, to which she returned after a few minutes.

The female moths do not seem to be strongly attracted to peach orchards, and when released in open fields a few hundred yards from an orchard appear to be unaware of its presence, instead making circular flights in various directions as just described. Under these conditions the female moth acts as though there certainly should be a peach tree at the exact place where she was released, and invariably she will return to that point after making a flight. Within the orchard oviposition is not confined entirely to peach trees, but eggs are placed on grass, weeds, stumps, sticks, dead twigs, leaves of various plants, and soil.

Male peach borer moths are strong, swift flyers and will go wherever the odor of the female lures them. Marked males have been attracted to females for distances of six-tenths of a mile against a moderately strong wind over open corn and cotton fields. It is reasonable to believe that after they have reached this point they could be lured the same distance to another point farther on. This would indicate that male moths from one orchard may visit another orchard, where the distance is not too great, and, in localities where peach orchards are fairly close together, may travel considerable distances from the orchard in which they emerged.

OLIVER I. SNAPP and J. R. THOMSON, JR., *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*—12-16-36.

A Scotch Pine Weevil, *Hylobius radicis* Buchanan.[1]—Grubs of this weevil caused damage to mature Scotch and Austrian pine trees on private estates and nurseries on the north shore of Long Island during 1935 and 1936. This species is closely related to the Pales weevil, *H. pales* Herbst, and the type of injury closely resembles that which has been described in the literature as resulting from the latter. Injury consisted of feeding at the base of the trunk, just beneath the soil level, and around some of the larger roots. Sometimes the grubs fed deeply into the wood on one side of the trunk. In other cases, complete girdling occurred. Feeding was known to progress to such an extent that the trees were

[1] Identification through the courtesy of L. L. Buchanan, U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

blown over by high winds. The new growth of injured trees is weak and the needles are often shorter than those on normal trees; advanced injury causes browning and subsequent dropping of many of the needles; and pitch, which exudes from the injured parts, infiltrates the surrounding soil.

Observations were made during 1936 on the habits of the insect. On May 12, larvae were about one-half inch in length and appeared to be from half to three-fourths grown on June 8. Many had pupated by July 23 although most of them were still in the larval stages. Some pupated beneath the bark, others in cells in the pitch-infiltrated soil surrounding the trunks of the trees. Two adults were dug out from around the trunks of Scotch pine July 25 and, from five trees examined August 22, 16 larvae, four pupae and 26 adults were obtained. Some of the adults were still beneath the bark although most of them were on the surface of the ground.

Table 1.—Larvae of *H. radicis* in Scotch pine.

Treatment	No. Trees	No. Live Larvae Recovered	No. Pupae Recovered
	Treated July 23, 1935; Examined June 8, 1936		
Lead arsenate	3	13	0
Soil removed	3	4	0
No treatment	3	25	0
	Treated June 9, 1936; Examined July 25, 1936		
PDB 1 oz.	6	20	2
PDB 2 oz.	6	18	0
Pineole Soluble–PDB 1 qt.	6	13	2
Pineole Soluble–PDB 2 qts.	1	1	1
Carbon disulfide emulsion 1 gal.	7	7	2
Soil removed	6	2	2
No treatment	6	17	34

An attempt was made to control the larvae by treating the soil immediately surrounding the crown of the tree. Several Scotch pine trees were treated in the fall of 1935, table 1. The soil was removed from around the bases of those treated with lead arsenate and then put back in place. The soil was removed from another set of trees and the bases of the trunks were left exposed. During 1936, several Scotch pine trees were treated with various materials. The paradichlorobenzeen was applied as in the treatment for peach borer. The liquid materials were poured into a trench around the base of the tree. The *Pineole Soluble* PDB mixture was prepared by dissolving 1 pound of PDB crystals in 1 quart of hot *Pineole Soluble*, then diluting to 4 gallons. The carbon disulfide emulsion was prepared according to the following formula and diluted at the rate of 1 part to 50 parts water.

Carbon disulfide 10 parts by volume
Rosin fish-oil soap 1 part by volume
Water 3 parts by volume

None of the materials tested gave a satisfactory degree of control. The fewest larvae and pupae were recovered from those trees from which the soil had been removed. The resultant exposure and desiccation of the crowns was apparently unfavorable for the development of the larvae. Most of the trees had been planted with 6 to 10 inches of soil above the uppermost roots.

The use of poison bait against the adults is suggested as a possible method of control.

Reference

Buchanan, L. L. 1934. An apparently new species of North American *Hylobius*, with synoptic key (Coleoptera: Curculionidae). Proc. Ent. Soc. Wash. **36**:252–6. 11 figs.

K. E. Maxwell and G. F. MacLeod, *Cornell University*.—11-13-36.

JOURNAL OF ECONOMIC ENTOMOLOGY

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THE ANNUAL MEETING

ONCE again entomologists from all parts of the country have met in annual session in conjunction with the meetings of the American Association for the Advancement of Science. The expense in time and money of attending this gathering, especially to those traveling long distances, was a considerable amount, and regardless of who paid the bill the cost was an item to be seriously evaluated. The question arises, therefore, as to the value of such conventions.

Examination of the recent programs of the two entomological societies meeting at Atlantic City reveals a listing of one hundred forty-two titles in addition to varied and numerous reports. It is obviously almost impossible for anyone to listen intently to all of these papers even if there existed no barriers to such a feat in overlapping sections. The thought is often expressed that there is no need to hear the papers at time of presentation because in most cases the manuscripts will be published and the articles can then be read to better advantage. A careful selection of those papers of most probable immediate interest or usefulness is the practical solution for this situation and a procedure followed by many members. Surely among all the varied subjects reporting progress, discoveries and the advancement of knowledge there are some which can improve the immediate usefulness and value of any entomologist. Publication of papers presented at annual meetings is usually a matter of some time and it is our observation that the leaders in the various fields of entomology are not content to wait months for printed articles in their special sphere of research if they can get this information first hand.

Some of the greatest values of the annual meeting are the opportunities presented for the renewal of old and the making of new acquaintances together with the informal discussions between individuals or small groups interested in particular fields of research.

There is still another value easily overlooked and one which at times can be the most important justification for such a gathering. This is the unconscious promotion of a mellowing influence which helps prevent the development of personal misunderstandings, sectionalism and organizational action of harmful potentialities. If the Atlantic City meeting accomplished nothing more than the forwarding of a reappraisal and thorough-going analysis of the effects of contemplated constitutional changes, concerning which widely divergent and antagonistic opinions had developed, the gathering was a signal success and of unquestionable value to entomologists and entomology.

Reviews

The Biological Control of Insects, by Harvey L. Sweetman. 1936. xii+461 pp., 6 portraits, 142 figs. Comstock Publishing Co., Inc., Ithaca, N. Y. $3.75.

For several years professional workers in biological control and teachers of economic entomology have felt the need of a compilation which would make easily accessible such knowledge as exists regarding the principles, methods, materials and achievements relating to this branch of applied biology. Professor Sweetman's volume is the first comprehensive effort toward this end, although in Europe two or three small volumes, such as Thompson's "Biological Control of Insect and Plant Pests;" Mercet's "Los Parasitos de Los Insectos Perjudiciales," etc., have appeared. None of these, however, has been presented as an exhaustive treatment of the subject. Sweetman's "Biological Control of Insects" covers the entire field, as may be judged from the chapter headings, the principle ones of which are: The theoretical basis of biological control; The use of resistant hosts; several chapters on the use of various types of organisms such as bacteria and fungi; viruses and protozoa; Nemathelminthes; Parasitic Hexapoda; Predatory Arachnida and Hexapoda; Some biological relations of insect parasites and predators; The introduction of insect parasites and predators; The use of predatory vertebrate animals; The results of biological control experiments against animals; and The biological control of pest plants.

To cover such an enormous field within the confines of a single volume of less than 500 pages calls for much condensation, with the result that a great deal of important detail, such as would be of interest and value to the professional entomologist engaged in biological control, has necessarily been omitted. For this reason the volume seems better adapted to use as a textbook for students than as a reference work for the professional entomologist. Since the author is primarily a teacher this is not surprising, and one looking for new material or original ideas will be disappointed. The extensive use of the contributions of entomologists engaged in this and related fields does not, of course, detract from the value of the book, but one familiar with the literature of the subject is struck by the conspicuous absence of quotation marks about paragraphs that have a familiar appearance.

The relation between the environment, the intrinsic characteristics of an organism and the population levels of the latter is an exceedingly complex relation, and generalizations on the subject must still in most cases be looked upon as hypotheses rather than as demonstrated truths. In most cases Sweetman shows commendable reserve in this regard, and the attitude of the author toward the subject is gratifyingly free of any attempt to "put over" the idea of biological control. He has attempted to present arguments on both sides of those phases of biological control which appear to be somewhat controversial and has left the reader to draw his own conclusions. This is as it should be, considering the present state of our knowledge of insect ecology. In some cases important arguments have been overlooked. For example, in the discussion of the relative value of parasites and predators, the ability of the entomophagous insect to discover its host in relation to the population density of the latter, a matter of decisive importance, is ignored. In general, both parasites and predators are winged in the adult stage, but many predacious species are handicapped by the fact that the young larvae have also to seek for hosts, while in most parasites this is not the case. The increase of the populations of entomophagous insects is determined by host density, and the density above which increase occurs is determined by the facility with which the predacious species finds the *succession of individual hosts necessary* to enable it to reach maturity. While a predatory larva individually destroys more than one host, this is a disadvantage rather than otherwise, since it necessitates that a succession of hosts *must* be found. Entomophagous insects whose non-flying stages must have a succession of host-individuals are severely handicapped as compared to winged parasites whose larvae develop in a single host-individual. Such predatory species require a much higher host density for survival and increase, so that, paradoxical as it may seem, the fact that predatory species destroy more hosts per individual than parasitic species makes them *less* efficient as control factors. In cases where predatory species, such as *Rodalia cardinalis*, have demonstrated their effectiveness, study will show that this result is due to the nature of the spatial distribution of the hosts rather than to the habits of the predator. Hosts which tend to develop in clusters tend to make predators relatively more effective.

The old question of the effects of multiple parasitism is left open to the extent that extreme caution is advised before two competing species be introduced. This advice is often given but just what form this "extreme caution" should take is never specifically stated.

The reviewer feels certain that many of the entomologists having responsibility for projects involving the introduction of entomophagous species would be interested in specific recommendations. The species which is dominant in one environment very often is not dominant in another. It is impossible to determine either by laboratory studies or by studies in the native habitat of a group of parasites which parasite would be most effective in another environment, for while one might conceivably duplicate the physical environment in the laboratory, this cannot be done with the biotic environment. Furthermore, there is no essential difference, in the effect on host abundance, between introducing two "directly" competing species and introducing an internal parasite and a predator which feeds on the host whether it is parasitized or not; or in introducing two species which compete for the same host in two different stages of development. To *prevent* the development of a parasite by destroying a host-individual differs little, if any, quantitatively from *destroying* the parasite in its immature stages. In any case, what it ultimately amounts to is that the rate of increase of the non-dominant parasite (or predator) is reduced. But a reduction in the rate of increase of the enemy insect does not necessarily affect the population level of the host; it only affects the length of time necessary to reach the new equilibrium position, a matter of little economic importance. Actually *all* of the enemies and diseases of a host species are in competition with each other.

The statement (p. 277) that the essential quality of a successful parasite or predator is a greater effective reproductive rate than that of its host is true only insofar as its effect on the amplitude of oscillations in the host population is concerned. If the host has reached stability, its average rate of increase is zero. When a new parasite is established and after it reaches stability, its rate of increase is also zero, and this is true no matter what effect its introduction has had on the average population level of its host.

The idea that in some cases many years may elapse after the introduction of a parasite before the host will be brought under control is hardly supported by actual experience. In every really successful case known to the reviewer, with the possible exception of the control of the coconut scale in Fiji, it has become evident within a very short period, usually about two years, that the introduction would probably be effective. The cases cited by Sweetman (p. 278) are the introduction of the Hessian fly parasite, *Pleurotropis metallicus*, in the United States in 1894 and its recovery only after 22 years; and the introduction of *Scutellista cyanea* into Louisiana in 1898 and its recovery in 1923. These cases would be convincing only if there is evidence to show that they were actually *established* as a result of these early introductions and that they had persisted during all the intervening time. Sweetman points out, of course, that so far as *Scutellista* is concerned, it could very easily have been reintroduced, accidentally, from California where it has occurred in great abundance since 1902. This is much more likely to be the true explanation than the one that the species took 25 years to build up to the point where it could be recovered.

The suggestion (p. 313) that the liberation of "pest larvae" containing parasites might in some cases be advisable seems dangerous, unless the larvae have been reared and parasitized in such a way as to avoid their being attacked by hyperparasites. Secondaries having habits similar to those of *Perilampus* and *Mesochorus*, which attack the primaries only indirectly through the caterpillar, could very easily be established in a new habitat by such a procedure.

It is a mistake to synonymize the term *superparasitism* with hyperparasitism and multiple parasitism. They have little in common, a fact fully appreciated by Fiske, which caused him to suggest the term and define it. Superparasitism is, of course, more nearly related to multiple parasitism, from which it is distinguished, however, by the fact that all the parasites belong to one species, whereas in multiple parasitism two or more species are involved. Etymologically, the adoption of the term *superparasitism* may have been ill advised because of its similarity in meaning to hyperparasitism, but it certainly represents a distinct biological phenomenon which should have a name.

Inclusion of the use of resistant hosts in the field of biological control is of doubtful advisability. While it is true that host resistance is a biological phenomenon, so is death by use of an insecticide, and any method of insect control has its important biological aspects. It would be better, in the opinion of the reviewer, to limit the field of "biological control" to the use of enemies and diseases. The training of experts in the development of pest-resistant hosts is not at all similar to that of workers with parasites, predators and diseases, and it is not likely that many investigators can be satisfactorily trained in *both* fields.

It is unfortunate that the portrait with the caption "Dr. W. R. Thompson" is not that of Dr. Thompson.

In reviewing a book such as this, the tendency is to criticize and largely to overlook its good points. The comments which appear above are intended primarily to emphasize to students the view that biological control, as a branch of science, is still very much in its infancy and that there is as yet very little about the subject which can be dignified by such terms as "principles" or "laws." For this reason they must be encouraged to keep open minds and to postpone accepting as facts many of the commonly held notions about the subject which are in reality only hypotheses, the correctness of which remains to be demonstrated. Biological control must either wait on ecology or its devotees must adopt the ecological approach before its principles can be definitely established.

"The Biological Control of Insects" will find its greatest usefulness as a text for students of entomology and for entomologists whose interest in the subject is only a general one. To professional entomologists working in the field covered by the book, the chapters on diseases, parasitic worms, etc., will be of most value, since the literature on these subjects is scattered and not easily accessible to them.

I shall recommend the book to entomological students as an introduction to the subject.

HARRY S. SMITH.—1-16-37.

Diseases of Bees. The report of a conference held at Rothamsted on September 26, 1936, under the Chairmanship of Sir E. J. Russell, D. Sc., F. R. S., Rothamsted Experimental Station, Harpenden. 43 pp.

This pamphlet consists of copies of papers read at this conference. The first by Dr. H. L. A. Tarr reviews the work at Rothamsted for three years in diagnosis and a study of the causes of brood diseases. He finds that the feeding of vegetative stages of *Bacillus larvae* alone does not cause American foulbrood to appear, but that the disease is readily caused by the feeding of spores. His other findings are generally in accord with investigations made in the United States. Dr. G. D. Morison, Aberdeen, reports on the so-called bee paralysis, presenting some evidence that this condition is due to inclusion bodies. There is such great diversity of symptoms and of opinions about this vague condition that progress is difficult. Dr. Otto Morgenthaler, Bern, Switzerland, was a special guest of the conference and discussed the disease situations in his country, with special reference to the extra-governmental disease insurance supported by Swiss beekeepers and devised and maintained for years under the management of Dr. Fr. Leuenberger. Morgenthaler maintains that European foulbrood is increasing in Switzerland and that the methods of control used so successfully in this country are not fully effective in Switzerland. In his paper there is an implied criticism of the prevailing American policy of burning for the control of American foulbrood, since he finds the shaking treatment entirely satisfactory if properly done. The last paper, by Jas. I. Hambleton of the Bureau of Entomology and Plant Quarantine, summarizes the results of investigations and experiences in the United States. He advocates burning of colonies infested with American foulbrood. The formation of a bee-disease insurance company in Great Britain in announced, on the lines of Swiss experience. The purpose of this conference was to clarify a confused state of affairs in Great Britain with respect to bee diseases, and it is to be hoped that it may help to accomplish this purpose.

E. F. PHILLIPS.—12-21-36.

Obituaries

Fenner S. Stickney 1892–1936

Dr. Fenner S. Stickney suffered a heart attack on the night of August 12, 1936, and died August 15. He was born August 6, 1892, at Wilson, N. C., and received his early training in North Carolina and Hawaii. He received the bachelor of science degree from the University of California in 1916, and from the University of Illinois he received his master's degree in 1918 and the doctorate in 1921. Dr. Stickney had also undertaken advance work in Stanford University. During the World War he served with the Sanitary Corps.

In 1921 Dr. Stickney undertook the study of scale insects of date palms in the Coachella valley in California for the federal Horticultural Board. These studies, continued under the Board of Entomology, were broadened to include other insects and mites of dates, and at

completion of this work he was transferred to the Bureau laboratory at Whittier, Calif., for study of citrus red scale.

B. L. BOYDEN.—11-6-36.

Clarence W. Lewis circ. 1883–1936

Clarence W. Lewis died August 19, 1936, following hospitalization for an acute stomach disorder. He was born at Melrose, Mass., about 53 years ago. At Massachusetts Agricultural College, from which he received the bachelor of science degree, he was prominent in athletics, particularly football.

Mr. Lewis entered the Department of Agriculture December 23, 1918, and until his death was engaged in various control projects with the Bureau of Entomology and Plant Quarantine. In recent years he served with the Transit Section of the Bureau at Philadelphia, and had been transferred to New York just before his death.

Funeral services with Masonic rites were held in Melrose, August 23.

WM. H. FREEMAN.—11-7-36.

Cyrus R. Crosby 1879–1937

Professor Cyrus R. Crosby, extension entomologist in the College of Agriculture at Cornell University, died suddenly on the evening of January 11, 1937, at Rochester, N. Y., where he had gone to attend a meeting of the Western New York Horticultural Society. On his birthday, only two days before, he had entertained at his home in his usual jovial manner a company of colleagues and neighbors.

Professor Crosby was born January 9, 1879, at Penn Yan, N. Y. After graduating from Cornell University he was engaged until 1906 as assistant entomologist at the University of Missouri. Returning to Cornell in 1906 he held successively the positions of assistant in the experiment station, assistant professor of entomological investigations, and finally from 1913 that of extension entomologist.

Professor Crosby has written extensively on subjects related to his field. He collaborated with Professor M. V. Slingerland on a widely used text on fruit insects, and with Dr. M. D. Leonard on a text dealing with vegetable insects. He also wrote, either alone or in collaboration with others, a number of experiment station circulars and bulletins. Although his time was chiefly given over to his activities as extension entomologist, he nevertheless found time—evenings, holidays and vacations—to devote to his hobby of studying spiders, a group in which his interest was first aroused by Professor J. H. Comstock and in which he had become a leading authority. His work is marked by meticulous care.

Though physically rather deliberate he exhibited an astounding intellectual alertness, a tireless industry, and an unbounded enthusiasm which was an inspiration to the young men with whom he was associated. The catholicity of his tastes was shown by his interest in philosophy, religion, anthropology, geology and other subjects outside of the field of his profession. He was a member of the Association of Economic Entomologists, of the Entomological Society of France, and a Fellow of the Entomological Society of America.

In the passing of Professor Crosby his friends and neighbors have lost a genial and entertaining companion, his associates in the Department of Entomology of Cornell University an efficient and helpful colleague, and his wife and son a devoted husband and father.

O. A. JOHANNSEN.—1-20-37.

Current Notes

CONFERENCE OF STATE OFFICIALS CONCERNED WITH INSECT CONTROL OPERATIONS

Entomologists representing thirteen states and the federal Bureau of Entomology and Plant Quarantine met in Omaha, Neb., December 4 and 5, 1936, to discuss the present grasshopper situation in the United States, and to confer on a program for 1937. Also discussed were methods of making egg surveys, types of baits used in different states, possible infestation in 1937 and advisable measures for handling the situation.

Commissioner of Agriculture W. B. Banning of Nebraska was chairman for the first two sessions of the conference, and on the second day Ray Murray, former Director of Agriculture of Iowa, was chairman.

The unparalleled number of grasshopper eggs now in the ground is part of the situation as depicted by the states and the federal Bureau to show that 1937 might easily witness a

major outbreak of grasshoppers, perhaps one of the greatest since any records of crop production have been kept.

The following resolutions committee reporting as given below, had in mind principally establishment of a fund to prevent the waste incurred by last-minute appropriations, often expended in such short time that the best use cannot be made of the funds allotted.

Chairman, Professor M. H. Swenk, Head, Department of Entomology, University of Nebraska, Lincoln, Neb.; Dr. C. J. Drake, Head, Department of Zoology and Entomology, Iowa State College, Ames, Iowa; Dr. A. L. Strand, Head, Department of Entomology, State College, Bozeman, Mont.; Dr. E. G. Kelly, Extension Entomologist, Kansas State Agricultural College, Manhattan, Kan.; Professor Chas. F. Stiles, Department of Entomology, Oklahoma A. & M. College, Stillwater, Okla.; Dr. E. L. Chambers, State Entomologist, State Capitol, Madison, Wis.; W. P. Flint, Natural History Survey, Urbana, Ill.

REPORT OF THE RESOLUTIONS COMMITTEE

WHEREAS, Emergency federal appropriations for aid in the control of regional insect outbreaks usually become available too late seasonally to be used with maximum efficiency and economy, therefore be it

RESOLVED, That this Conference urges that the 1937 Congress establish, and subsequent Congresses maintain, a fund of $5,000,000 to be replenished to the original amount at the beginning of each fiscal year whenever such replenishment is necessary, to be available to and administered by the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture for the financing through advance options, or storage, and subsequent distribution to the affected states, through cooperation with the proper officials of the states concerned and upon adequate set-off commitments of these states, of insecticides and other usable materials, equipment, transportation, distribution and application, administrative costs and other expenses incidental to accomplishing the control of grasshoppers, chinch bugs, and other insect pests similarly subject to interstate migratory movements, or intermittent regional outbreaks affecting several states (but exclusive of purely intrastate or local outbreaks), or emergency insect outbreaks that threaten the agricultural interests of several states, if and when the need and desirability for such federal aid is satisfactorily established through the approval of competent technical committees, the Secretary of Agriculture and other proper governmental agencies; and

WHEREAS, Fundamental research is the essential basis of further progress toward the solution of the more pressing problems of grasshopper control, and at the present time the federal and state research programs along this line are much too restricted and exceedingly inadequately supported financially, therefore be it

RESOLVED, That a more intensive and extensive long-time research program on grasshopper biology, ecology and control be inaugurated and carried out, both by the several infested states and the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture, with special emphasis upon the fundamental factors that cause grasshopper epidemics, and including grasshopper surveys and studies designed to develop cheaper and more effective poisoned baits; and

WHEREAS, Various species of grasshoppers have since 1933 destroyed millions of acres of range and grassland forage and have been responsible for great additional financial losses to stockmen, occasioned by the forced sale or movement of livestock, and

WHEREAS, The control of range grasshoppers is of extreme importance in any intelligent soil conservation and range management program, and in the prevention of soil erosion, and

WHEREAS, Control of these range grasshoppers is at the present time apparently not always economically profitable, and

WHEREAS, Knowledge as to the habits, life histories and ecological relations of these species is very fragmentary, therefore be it

RESOLVED, That the United States Department of Agriculture be urged to continue and to expand its investigational work on the range species of grasshoppers, and from time to time carry out such large-scale experiments on actual control as may seem desirable, and that such additional funds as may be necessary be appropriated to the Department of Agriculture by the Congress for the accomplishment of these objects.

ROCKY MOUNTAIN CONFERENCE OF ENTOMOLOGISTS

The thirteenth annual Rocky Mountain Conference of Entomologists was held in the University of Wyoming summer camp, Centennial, Wyo., August 16 to 21. The University of Wyoming summer camp is located in the forest of the Medicine Bow mountains at an altitude of about 10,000 feet.

Members of families joined in the meeting. A total of 97, representing 17 states, were present. Most of those present arrived at the camp on Sunday and remained until Friday. Meals were served in the camp lodge and sleeping quarters were furnished in cabins located along a mountain stream.

Following is a list of those present who were directly interested in entomology:

ARIZONA
Stitt, Loyd L.

COLORADO
Daniels, Leslie B.
Davis, Louis G.
Heiss, Elizabeth
Hinkle, Galen
Hoerner, John L.
James, Maurice T.
Jones, C. R.
List, Geo. M.
Maxson, Asa C.
McCampbell, Sam C.
McLaughlin, Eleanor Davis
Newton, J. H.
Palmer, Miriam A.
Reed, Elmer
Sisson, Max A.

ILLINOIS
Bigger, J. H.

INDIANA
Davis, J. J.

IOWA
Richardson, C. H.

KANSAS
Goodrich, Arthur L.
Kelly, E. G.
Painter, Reginald H.

MINNESOTA
Parten, H. L.

MISSOURI
Haseman, Leonard
Voris, Ralph

MONTANA
Butcher, Fred D.
Mabee, W. B.
Parker, J. R.
Shotwell, Robert L.

NEBRASKA
Gates, L. M.
Wade, Otis

NEW YORK
Post, R. L.
Rosenbauerer, Elvira

OKLAHOMA
Fenton, F. A.

UTAH
Hamlin, John C.
Henderson, W. W.
Reeves, Geo. I.
Sorenson, C. J.
Stanford, J. S.

SOUTH DAKOTA
Severin, H. C.

VIRGINIA
Schoene, W. J.

WISCONSIN
Fluke, C. L.

WYOMING
Clarke, L. Floyd
Corkins, C. L.
Farrar, C. L.
Gilbert, C. H.
Greenwald, Margaret
Hitchcock, John D.
Owen, Wm. B.
Scott, John W.
Sturtevant, A. P.
Woodrow, A. W.

Eight sessions were held for discussions and the reading of papers. The following were the more formal subjects:

"The Cairo, Egypt, International Grasshopper Conference," J. R. PARKER.

Reports of the Grasshopper Conditions and the Research and Control Work by States:

COLORADO
S. C. McCampbell

ILLINOIS
J. H. Bigger

INDIANA
J. J. Davis

IOWA
C. H. Richardson

KANSAS
E. G. Kelly

MISSOURI
Leonard Haseman

NEBRASKA
L. M. Gates

NORTH DAKOTA and MONTANA
Fred D. Butcher

OKLAHOMA
F. A. Fenton

SOUTH DAKOTA
H. C. Severin

WYOMING
C. L. Corkins

"The Grasshopper Problem," FRED BUTCHER.
"Grasshoppers in Oklahoma," F. A. FENTON (Motion Picture).
"The 1936 Grasshopper Control Campaign in Jefferson County, Colo.," L. G. DAVIS.

"Grasshopper Adult and Egg Surveys," R. L. SHOTWELL.
"Ecology of Grasshoppers," H. C. SEVERIN.
"Intensive Area Studies of Grasshoppers," J. R. PARKER.
"Laboratory Studies of Grasshopper Baits," C. H. RICHARDSON.
"Florissant Diptera," M. T. JAMES.
"Staphylinid Beetles," RALPH VORIS.
"Syrphidae Studies," ELIZABETH M. HEISS.
"Bombyliidae and Certain Other Diptera," R. H. PAINTER.
"Aphids," M. A. PALMER.
"Orthoptera Classification," W. W. HENDERSON.
"Plant Lice of the Sugar Beet," A. C. MAXSON.
"The Need of Keys for the Common Insects of the Rocky Mountain Region," J. W. SCOTT.
"Geology of the Rocky Mountain Region," S. H. KNIGHT.
"The Alfalfa Weevil Situation in Nebraska," L. M. GATES.
"The Codling Moth in Virginia," W. J. SCHOENE.
"The Influence of Weather on Codling Moth in Missouri," LEONARD HASEMAN.
"Spray Residue Removal," C. L. FLUKE.
"Codling Moth Control Work in Colorado," J. H. NEWTON.
"Codling Moth in Indiana," J. J. DAVIS.
"Peach Mosaic Control," MAX A. SISSON.
"Work of the Intermountain Bee Laboratory," A. P. STURTEVANT.
"Bee Behavior in Commercial Production," C. L. FARRAR.
"Extension Projects," E. G. KELLY.
"Lygus Bugs in Relation to Alfalfa Seed Production," C. J. SORENSON.
"Studies of Lygus Bugs in Arizona," LOYD L. STITT.
"The Tomato Psyllid as Related to Potatoes," L. B. DANIELS.
"The Tomato Psyllid as Related to Tomatoes," GEO. M. LIST.
"The Mormon Cricket Problem," C. L. CORKINS.
"The Sudden Rise of the Mormon Cricket Population," J. R. PARKER.
"A Progress Report on Control of Squash Bug, *Anasa tristis* De G.," J. L. HOERNER.
"Blister Beetles," H. C. SEVERIN.
"Mosquitoes," WM. B. OWEN.
"Resistance of Plants to Insect Attack," R. H. PAINTER.
"Enemies of Fish in Yellowstone National Park," JOHN W. SCOTT.

The selection of the meeting place for next year was left with the officers. Those selected for 1937 are C. P. Gillette, Chairman; Claude C. Wakeland, Vice-chairman; Geo. M. List, Secretary; and C. R. Jones, Treasurer.

GEORGE M. LIST, *Secretary, Rocky Mountain Conference of Entomologists.*—10-28-36.

CONFERENCE OF CONNECTICUT ENTOMOLOGISTS

By invitation, the thirteenth annual conference of entomologists working in Connecticut was held in Memorial Hall, Massachusetts State College, Amherst, Mass., on Friday, October 16, 1936, in connection with the exercises commemorating the fiftieth anniversary of the beginning of the work of Charles Henry Fernald. Neely Turner was elected chairman, and 98 persons were present. Luncheon was served in the college dining hall and the commemorative exercises followed the luncheon.

The following program was carried out:

Greeting, PROFESSOR C. P. ALEXANDER, *Amherst, Mass.*
"Some Entomological Features of 1936," W. E. BRITTON, *New Haven, Conn.*
"Results Accomplished in Gypsy Moth Work, 1936," S. S. CROSSMAN, *Greenfield, Mass.*
"Review of the Japanese Beetle Situation," I. M. HAWLEY, *Springfield, Mass.*
Natural Control of Insects (10-minute papers):

"Notes on Natural Enemies of Certain Orchard Pests," PHILIP GARMAN, *New Haven, Conn.*
"Investigations on Parasities of Forest Insects by the Bureau of Entomology at New Haven, Conn.," PHILIP B. DOWDEN, *New Haven, Conn.*
"Parasitism of the Squash Bug by *Trichopoda pennipes*," RAIMON L. BEARD, *New Haven, Conn.*
"Climatic Factors in Insect Control," HARVEY L. SWEETMAN, *Amherst, Mass.*

"Factors Important to a Successful Hibernation of the Corn Ear Worm," GEORGE W. BARBER, *New Haven, Conn.*
Discussion.
"The Apple Leaf-curling Midge," W. D. WHITCOMB, *Waltham, Mass.*

Fernald Commemorative Exercises.
Address of Welcome, PRESIDENT HUGH P. BAKER, *Amherst, Mass.*
Message from H. T. FERNALD, *Orlando, Fla.*
"A Tribute to Professor Charles H. Fernald," A. F. BURGESS, *Greenfield, Mass.*
"Professor C. H. Fernald and Fifty Years of Shade-tree Insect Control," E. P. FELT, *Stamford, Conn.*
"Carpenter Ant Injury to Telephone Poles," R. B. FRIEND, *New Haven, Conn.*
"Field Plot Experiments with Corn Borer Insecticides, 1936," C. H. BATCHELDER and N. TURNER, *New Haven, Conn.*

Horticultural Inspection Notes

REPORT OF THE CENTRAL PLANT BOARD

The Central Plant Board met in its twelfth annual meeting at Ames, Iowa, March 4, 1936. The National Plant Board accepted the invitation of the regional board and met with them in a joint meeting at the afternoon session.

Avery S. Hoyt, Assistant Chief of the Bureau of Entomology and Plant Quarantine, spoke to the group on "Some Accomplishments under the Emergency Work Programs Sponsored by the Bureau." Few members had previously realized the scope of this work and the progress that was being made in control and eradication work in the 48 states. Attention was also called to what might be termed the indirect value of this program in making the thousands of individuals who took part in this program acquainted, at least to a small degree, with the problems confronting the country in disease and insect problems. One outstanding example cited was the CCC enrollees who have had in almost every case some contact with this work and 673 CCC Camps that have been actively engaged in plant disease or insect problems.

The majority of the program of the Board was devoted to topics dealing with greater uniformity in inspection methods, standards and uniform quarantines. This question has been of major importance for years and in 1928 at St. Louis a set of recommendations was adopted which have been followed by the member states up to the time of the Ames meeting. Following the discussions by the several state representatives, Mr. Dawson chairman of the Uniform Regulations Committee, made his report on the revision of the standards adopted in 1928. The recommendations of the committee with some changes were adopted and published as "Report of Standing Committee on Uniform Requirements for Interstate Movement of Nursery Stock."

P. T. ULMAN, *Sec'y-Treas.*

REPORT OF SOUTHERN PLANT BOARD

No regular scheduled meeting of the Southern Plant Board was held during the current calendar year. A special meeting of the Board was held in Chicago on November 5 on the occasion of the conference of state and federal plant quarantine officials held at that place on the fifth and sixth of November. The subjects which were to be discussed at the general conference were considered in a preliminary way. The officers were re-elected, except that J. H. Montgomery was selected to act as one of the representatives of the Southern Plant Board on the National Board to replace M. S. Yeomans of Georgia, who had retired from state service. The Southern Board instructed its representatives on the National Board to continue efforts toward securing greater uniformity and standardization of plant quarantine requirements, with particular reference to the requirements involving interstate movement of plants and plant products.

REPORT OF THE EASTERN PLANT BOARD

The annual meeting of the Eastern Plant Board was held at the Hotel McAlpin, New York City, November 11, 1936, with 12 members and 19 visitors present.

The following committees were appointed by the President: Audit, F. W. Craig and J. F. Adams; Nominations, H. L. McIntyre, G. T. French and H. B. Weiss.

The following program was given.

"Progress in Dutch Elm Disease Work with Special Reference to Research," *L. H. Worthley.*

"Progress in Japanese Beetle Work with Special Reference to Research," *C. H. Hadley.*

"The Japanese Beetle from the Quarantine Angle," *L. H. Worthley.*

"The Status of the Gypsy Moth," *A. F. Burgess.*

"Azalea Flower Disease," *Richard P. White.*

"A Progress Report on the Suppression of the Alfalfa Snout Beetle in New York State," *A. B. Buchholz.*

"Foreign Plant Quarantine Activities at the Port of New York," *Max Kisliuk, Jr.*

The following resolutions were passed:

Moved by Adams and seconded by Stene that this Board request that the Secretary of Agriculture provide adequate funds for a thorough and extensive investigation of the Azalea flower spot disease. It was further moved by Lauer, properly seconded, and carried that the Executive Committee be instructed to follow up the question of activities with respect to the Azalea flower spot disease in any way that they deemed proper.

It was moved by Craig and seconded by Lauer that the Executive Committee be instructed to collect information, organize sentiment and do everything possible to secure adequate appropriations for eradication work on the potato wart disease.

It was moved and seconded that the Secretary of Agriculture be apprised of the keen interest of this Board in port inspection and be requested to provide, in the budget, increased funds for port inspection in proportion to the volume of work being done.

Moved by Cory, seconded by Craig and carried that:

WHEREAS, The apparent reduction of the Japanese Beetle in St. Louis and Erie, Pa., would seem to indicate that eradication measures offer promise, at least in isolated areas, and that the policy of treating isolated findings is a sound policy when coupled with local quarantines and should be continued, and

In order that the fullest knowledge with regard to spread may be known each year, the extensive trapping program should be continued and sufficient funds provided to enable the trapping of the constantly enlarging areas, and

WHEREAS, The old area continues to furnish the reservoir, the research program should be financed with increased amounts which will permit more vigorous prosecution of research in the sequence of treatments that may serve for control.

The following officers were elected: President, Dr. W. E. Britton, New Haven, Conn.; to the National Plant Board, J. F. Adams and R. H. Bell; Executive Committee, G. T. French, H. B. Weiss and R. H. Allen.

The Committee on Audit moved that the report of the Treasurer be accepted and approved. Passed.

Mr. Lauer spoke briefly in regard to the duplication of work in the inspection of parcels coming under the Japanese beetle certification, and Mr. Worthley replied that he would be very glad to enter into a cooperative agreement with any state that would protect the use of certificates.

On NOVEMBER 2, 1936, the federal Bureau of Entomology and Plant Quarantine, revoked the quarantine relating to the satin moth which affected parts of the New England States and of Washington. The insect has also recently become established in Oregon.

EFFECTIVE November 9, 1936, the domestic quarantine relating to the Dutch elm disease was amended to include new areas in Connecticut, New York and New Jersey.

FEDERAL regulations on the importation of potatoes were amended effective December 1, 1936, to place importations into Hawaii on the same basis as importations into continental United States and Puerto Rico.

THE FEDERAL quarantine (foreign) relating to the Mexican fruit fly (Quarantine No. 5) which prohibited the entry into the United States of specified host fruits of this insect, was lifted effective December 1, 1936. This revocation automatically places the fruits named in that quarantine under the provisions of Quarantine No. 56, the regulations of which were amended effective the same date. Under the latter quarantine these fruits will continue to be prohibited entry except when so treated as to eliminate pest risk.

American Association of Economic Entomologists

PROCEEDINGS OF THE FORTY-NINTH ANNUAL MEETING

Chalfonte-Haddon Hall, Atlantic City, N. J., December 28–31, 1936

The forty-ninth annual meeting of the American Association of Economic Entomologists was held at the Hotel Chalfonte-Haddon Hall, Atlantic City, December 28 to 31, 1936. Total registration was 253.

The Section of Apiculture met on the morning of the twenty-eighth, the Section of Extension on the evening of the twenty-eighth, and the Section of Plant Quarantine and Inspection on December 30.

There was a splendid symposium, presided over by Dr. L. O. Howard, on Insects Affecting Man and Animals, on the afternoon of the twenty-eighth, held jointly with the Entomological Society of America.

The Entomologists' Dinner, with an attendance of 286, was held on the evening of December 29, with Miss Edith M. Patch, of Orono, Me., delivering the annual address. E. A. Mechling discussed entomology in humorous style from the standpoint of the farmer. Dr. L. O. Howard was present and made a few informal remarks.

The general session for the reading of papers continued from Tuesday morning through Wednesday afternoon, and the final business session was held at 4:30 Thursday afternoon. Dr. F. C. Bishopp of the Bureau of Entomology and Plant Quarantine, Washington, D. C., was elected President for 1937.

The place of the next meeting was selected as Indianapolis, Ind., in conjunction with the meetings of the American Association for the Advancement of Science. The exact dates have not as yet been determined.

REPORT OF THE SECRETARY

Ernest N. Cory
College Park, Md.

The finances of the Association have been drawn upon for special items incident to the transfer of property, for increased size of the JOURNAL, and for clerical help to get the records into more usable form. Aside from these expenditures, the statement will show approximately similar receipts and expenditures to those of previous years. The auditor's report shows a balance as of December 15, 1936 of $8,950.24, of which $3,060.30 is in a savings account. The total is distributed as follows: JOURNAL $3,719.91, Association $3,585.17, Index V $402.50 (representing 50 cents per paid-up member set aside from 1936 dues towards the cost of Index V, which is to be distributed free to members who keep up their dues), Index IV $304.50, Index III $153.30, and Indices I and II $774.86.

Eight hundred five members have paid dues for 1936. Dues for 1936 and arrears running back as far as 1933, in a few cases, total $1171.50, most of which will undoubtedly be received.

Applications totalling 54 are to be considered by the Membership Committee. Death claimed eleven members, as follows:

John T. Bigham, Menard, Texas
A. N. Caudell, Washington, D. C.
J. W. Folsom, Tallulah, La.
M. H. Ford, Houston, Texas
W. F. Grossman, Gainesville, Fla.
W. E. Hinds, Baton Rouge, La.

C. W. Lewis, Philadelphia, Pa.
Albert P. Morse, Wellesley, Mass.
Fenner S. Stickney, Whittier, Calif.
Dr. Sigismund Mokrzecki, Skierniewice, Poland
Stephan Soudek, Brno, Czechoslovakia

There were 24 resignations and four members dropped. One thousand five members paid 1935 dues. There are 49 foreign members.

The change in Business Manager, Editor and printer involved some lost motion, but the JOURNAL is running smoothly at last, thanks to the very efficient work being done by the Editor. Eleven hundred ninety-one pages have been printed, the advertising shows a slight increase, and all back manuscripts have been printed. The report of the Advisory Committee of the JOURNAL will give detailed information and recommendations.

Reports of the Cotton States, North Central States, Pacific Slope and Eastern Branches follow.

The report of the Executive Committee will describe the numerous activities entailed by several changes ordered by the previous Executive Committee and much that would otherwise be included in this report would, therefore, be duplication.

SUMMARY OF CASH RECEIPTS AND DISBURSEMENTS AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

For the Period from December 14, 1935 to December 15, 1936

	TOTAL	JOURNAL	ASSOCIATION	INDEX V	INDEX IV	INDEX III	INDEX I AND II
Balance, December 14, 1935, as per previous report	$ 7,514.87	$ 3,340.39	$2,921.08		$328.27	$163.51	$761.62
Receipts:							
Sales	133.50				48.35	35.85	49.30
Subscriptions, advertising, and reprints	8,840.23	8,840.23					
Dues and miscellaneous	2,707.10		2,304.60	$402.50			
Interest on bank deposits	60.30		60.30				
	$19,256.00	$12,180.62	$5,285.98	$402.50	$376.62	$199.36	$810.92
Disbursements:							
Audit of period Dec. 9, 1934, to Dec. 14, 1935	$ 35.00		35.00				
Printing	6,645.94	6,548.54	97.40				
Engravings, halftones, drafting, etc.	563.01	563.01					
Editor's salary (1936 and last six months of 1935)	300.00	300.00					
Salary of Secretary and Business Manager	400.00	200.00	200.00				
Clerical work	744.34	473.44	270.90				
Postage, stationery, and supplies	509.26	215.93	293.33				
Telephone, telegraph, freight and express	119.78	84.64	35.14				
Expenses of boxing and shipping material from Massachusetts to Maryland incidental to a change of secretaries	202.33	6.50	51.59		72.12	36.06	36.06
Travelling expenses to meetings of Executive Committee	53.65		53.65				
Other travelling expenses:							
A. I. Bourne, to College Park, Maryland	38.59		38.59				
E. N. Cory to New York City	20.13		20.13				
T. H. Frison to Menasha, Wisconsin	18.75	18.75					
Stenographic report	83.23		83.23				
Branch expenses	49.22		49.22				
Refunds	10.50	10.50					
Purchase of filing cabinet	39.40	39.40					
Surety bond of Secretary	19.73		19.73				
Association badges	20.91		20.91				
Rental of safe deposit box	1.38		1.38				
Bank collection charges	5.61		5.61				
Transfer to Permanent Fund	425.00		425.00				
	$10,305.76	$ 8,460.71	$1,700.81		$ 72.12	$36.06	$ 36.06
Balance, December 15, 1936	$ 8,950.24	$ 3,719.91	$3,585.17	$402.50	$304.50	$163.30	$774.86

The balance is deposited as follows:

Prince Georges Bank and Trust Company, Hyattsville, Md. (checking account)	$5,889.94
First National Bank of Amherst, Mass. (savings account)	3,060.30
	$8,950.24

College Park, Maryland
December 22, 1936

Dr. E. N. Cory, Secretary
American Association of Economic Entomologists
College Park, Maryland
Dear Dr. Cory:

I have supervised the audit of the accounts of the American Association of Economic Entomologists for the period from December 15, 1935, to December 15, 1936. In connection therewith, the cash book record of receipts has been verified by tests; and the cancelled checks have been compared with the vouchers and with the cash book record of disbursements.

All bank deposits of both the General Fund and the Permanent Fund have been verified by positive confirmations from the depositary banks. All interest receipts have been confirmed in like manner. The securities have been verified by examination and all interest coupons accounted for. The Secretary's computation of the amount of dues to be allocated to Index V has been accepted.

I hereby certify that, in my opinion the accompanying statements properly set forth the cash receipts and disbursements for the period of this audit and the balance in custody of the Secretary on December 15, 1936.

(Signed) S. M. WEDEBERG,
Certified Public Accountant

PERMANENT FUND, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

For the Period from December 14, 1935, to December 15, 1936

Balance, December 14, 1935, as per previous report			$16,856.97
Receipts			
Interest from securities		$ 437.50	
Interest from savings deposits		57.47	
Transfer from Association funds		425.00	
			919.97
Balance, December 15, 1936			$17,776.94

The balance is invested as follows

Par Value	Securities		
$3000	U. S. Treasury Bonds, 2¼%	$2,984.00	
2500	U. S. Treasury Bonds, 3¼%	2,484.00	
5000	U. S. Savings Bonds	3,750.00	
4000	Federal Land Bank of St. Louis 4¼%	3,550.00	
2000	Province of Ontario, 5%	2,000.00	
			$14,768.00
Bank deposits (savings accounts):			
	Prince Georges Bank and Trust Company, Hyattsville, Maryland	$1,926.30	
	Franklin County Trust Company, Greenfield, Massachusetts	1,082.64	
			3,008.94
			$17,776.94

The Permanent Fund was increased by the transfer of $425 from Association funds and by interest of $494.97. It is increasingly difficult to secure adequate safe investments yielding good interest. Bank interest continues to decline.

ERNEST N. CORY, *Chairman*

REPRESENTATIVES ON THE COUNCIL OF THE UNION OF AMERICAN BIOLOGICAL SOCIETIES

At a meeting of the Council of the Union of Biological Societies on the night of December 28 the status and future of *Biological Abstracts* was fully discussed. It was reported that as a result of the most drastic economies the continuance of the abstracts and indexes through the year 1937 is assured but the issuance of the *Abstracts* must cease at the end of that year unless further substantial financial support is extended. The feeling was expressed that if biologists as a whole would show a more active interest in *Biological Abstracts* and lend more financial support that the chance of securing further grants would be much better.

It was pointed out that the American Society of Zoologists had voted to assess each member a definite amount per year for the support of the *Abstracts* and it was suggested

that the representatives of each of the member societies present to their respective societies the urgent need of having early evidence of general interest in and support of the publication. The associations were asked to consider an assessment of $1 per member. It was indicated that if that plan was not acceptable that any amount voted by the associations would be helpful in carrying on the work in 1937 and would serve as a basis for requesting further outside assistance.

In the absence of Mr. Crosby the other member of your Committee, I present this matter for the consideration of the Association and such action as it may care to take.

F. C. BISHOPP

[This report was read at the final business meeting by Dr. F. C. Bishopp, and is included herein. The report was accepted, after considerable discussion, with the amendment that the matter of contribution to the publication of *Biological Abstracts* be left to the Executive Committee for investigation and action.]

TROPICAL PLANT RESEARCH FOUNDATION

[Dr. Herbert Osborn was not present to submit the report of the Board of Trustees of the Tropical Research Foundation and, therefore, that report was passed over.]

EASTERN BRANCH

The Eastern Branch of the American Association of Economic Entomologists met in New York City on November 12 and 13 at the Hotel McAlpin, with Phillip Garman presiding. A program of 38 papers was carried through, including a very interesting symposium on termites, participated in by Neely Turner, George E. Sanders, R. A. St. George, T. J. Headlee, D. G. Muirhead and John L. Tappin. About 172 members registered.

The financial report showed receipts of $1,564.74 and expenditures of $130.70.

H. N. Worthley was elected Chairman, V. I. Safro, Vice Chairman, and Harry B. Weiss continued as Secretary-Treasurer.

COTTON STATES BRANCH

The Cotton States Branch held its eleventh annual meeting at Jackson, Miss., February 5 and 6, with approximately 75 members in attendance. A program of 33 papers was carried through, including 12 papers on cotton insects.

The Secretary-Treasurer, O. I. Snapp, Fort Valley, Ga., reported receipts of $247.74, expenditures of $36.82, leaving a balance of $210.92.

W. E. Anderson, Baton Rouge, La., was elected Chairman, W. E. Dove, San Antonio, Tex., Vice Chairman, and Oliver I. Snapp was continued as Secretary-Treasurer.

PACIFIC SLOPE BRANCH

The meetings of the Pacific Slope Branch were held at the University of Washington, Seattle, Wash., on June 18 and 19, under the Chairmanship of Dr. H. A. Scullen, Corvallis, Ore. Between 50 and 60 members and persons interested in entomology attended the various sessions. Thirty-five papers were listed on the program and the invitation address was presented by Professor R. W. Doane of Stanford University, who gave a most interesting talk on "Forty-Five Years of Entomology."

Some most interesting papers were read, four of which were devoted to the codling moth. On the evening of the eighteenth the banquet was held, at which about 40 were present. Short addresses were made by a number attending.

In addition to members resident on the Pacific coast, there were a number of entomologists present from much farther afield, including Dr. Chapman from Hawaii, Dr. Roark from Washington, D. C., Drs. Crosby and MacLeod from Cornell University, Mr. Fenton from Texas, and Dr. L. S. McLaine, President, from Ottawa, Can.

The Secretary-Treasurer, J. F. Lamiman, reported receipts of $36.03 and expenditures of $16.99, leaving a balance of $19.04.

E. J. Newcomer, Yakima, Wash., was elected Chairman of the Branch, J. R. Eyer, Vice Chairman, and J. L. Lamiman, Davis, Calif. was continued as Secretary-Treasurer.

E. N. CORY, *Secretary of the Association*

It was moved, seconded and carried that the report of the Secretary be adopted as read.

REPORT OF THE EXECUTIVE COMMITTEE

(1) During the year the Executive Committee held four meetings: February 10, New York; November 10, New York; December 27 and December 29, Atlantic City.

(2) Recommendations of the Executive Committee which were approved and adopted by the Association at large at the St. Louis meetings were put into effect.

(3) Suggestions were drawn up for a revision of the constitution and by-laws in accordance with the instructions of the Association at the St. Louis meeting. The suggested revision has been distributed to the membership and in accordance with the present constitution has been referred to a special committee which will report to the Association.

(4) An invitation was extended to and accepted by the Executive Committee of The Entomological Society of America to meet the Executive Committee of this Association to discuss matters of mutual interest to the two organizations.

(5) The contract for the printing of the JOURNAL OF ECONOMIC ENTOMOLOGY by the George Banta Publishing Company, Menasha, Wis., was approved. Arrangements were made with the printers for the storing of back numbers of the JOURNAL, and the distribution of back numbers on instructions from the Secretary. Arrangements were also made for the disposition of cuts, electrotypes and zinc etchings which had accumulated over a period of years. The Editor of the JOURNAL was authorized to arrange for the printing of the accumulated manuscripts on hand. The revised rates for advertising matter in the JOURNAL, suggested by the Business Manager, were approved.

(6) The Secretary was authorized to re-instate members of the Association dropped for nonpayment of dues upon payment by them of any arrears.

(7) Through the cooperation of the Bureau of Entomology and Plant Quarantine, Miss Colcord proceeded with the compilation of references for Index V. Dr. E. P. Felt kindly consented to act as Editor of this publication and was so appointed. Although the manuscript prepared covers a period of seven years, it was decided to confine the volume to a period of five years, on account of the large increase in the number of references and the additional cost of printing involved. As 50 cents additional fees have been transferred to the Index V fund, a copy of the volume will be distributed free to members in good standing.

(8) The Executive Committee desires to express its appreciation to the Committee on the Codling Moth for arranging its conference at the time of the annual meeting, as was previously recommended by the Executive Committee.

(9) The Executive Committee desires to place on record the appreciation of the Association for the efforts of the Secretary and Editor of the JOURNAL, who carried out their duties in a most capable manner in spite of the many difficulties encountered.

(10) The Executive Committee at its open session received the reports of the following committees and ordered them to be published in the JOURNAL.

(a) Committee on Common Names of Insects.
(b) Committee on Insect Collections.
(c) Committee on Research Work on Control of the European Corn Borer.
(d) Committee on Control of the Codling Moth.
(e) Committee on Advancement of Official Entomology.
(f) Committee on Popular Entomological Education.
(g) Committee on Publication of Index V.

(11) No reports were received from the following committees.

(a) Representative to the National Research Council.
(b) Councillors for the American Association for the Advancement of Science.
(c) Representatives on Council of Union of American Biological Societies.
(d) Representative on Board of Trustees of Tropical Plant Research Foundation.
(e) Committee on Insecticide Terminology.

(12) Upon the recommendation of the Chairman, the Committee on Research Work on Control of the European Corn Borer has been dropped from the list of standing committees.

(13) Upon the recommendation of the Committee, the name of the Committee to Formulate Plans for Investigation of the Codling Moth from Biologic and Control Standpoints, has been changed to the Committee on the Codling Moth.

RECOMMENDATIONS

(1) In addition to the interest on Association Funds of $60.30, $439.70 from the Association funds be transferred to the Permanent Fund, making a total transfer of $500.

(2) The terms of the present members of the Committee on Common Names be termi-

nated, and that there be elected six members, two with terms of three years, two with terms of two years, and two with terms of one year each; two members to be elected each succeeding year for a three-year period.

(3) There be established a standing committee on Program, consisting of three members to be elected with terms of three, two and one years; one member to be elected each succeeding year for a three-year term. The function of this committee shall be to arrange the special features of the program and to make general recommendations to the Executive Committee in regard to the program.

(4) That the Editor be authorized to engage editorial assistance and clerical help in an amount not to exceed $600 and the Secretary be allowed to expend $250 on clerical assistance.

COMMITTEE ON COMMON NAMES

Of the list of 125 common names submitted at the meetings last year, 89 received sufficient votes for approval; and of the 11 changes suggested, five were approved.

The names approved this year have been incorporated with those previously adopted. Owing to lack of space in the JOURNAL, the list has not been published. It will appear in the JOURNAL in the near future, and also as a separate.

No names are being submitted at this time.

J. A. HYSLOP, *Chairman*
E. O. ESSIG
H. B. HUNGERFORD
H. G. CRAWFORD

COMMITTEE ON INSECT COLLECTIONS

[Dr. T. H. Frison, chairman, had no formal report to present. He recommended that until private collections increased, no formal report be made. His recommendation was accepted, and in connection with his report J. J. Davis noted the purchase of the Blatchley collection by Purdue University.]

COMMITTEE ON RESEARCH WORK ON CONTROL OF THE EUROPEAN CORN BORER

The European Corn Borer Committee of the American Association of Economic Entomologists met at Toledo, Ohio, September 4 and 5, and carefully reviewed the investigations to date, with special reference to the work of the past season.

The recommendations of your committee made a year ago (JOURNAL 29(1):235-6. Feb.) have been adopted and closely followed by the workers of the Bureau of Entomology and Plant Quarantine, with marked valuable results. We commend the federal authorities on the progress made during the past season.

Present status.—A study of previous reports clearly shows that in most of the last six or eight years, weather conditions have been abnormal and unfavorable to borer development and increase in the one-generation area of the central west. Yet in spite of unfavorable seasons the borer showed increases, except in the years 1930 and 1934, when exceptionally severe heat and drouth noticeably reduced numbers in most regions of this area. In 1935, however, conditions were quite favorable to the insect and it increased to numbers approximately equal to the years previous to 1934. The favorable 1935 season has been followed by a season which has been most unfavorable over a large part of the one-generation area, resulting again in a notable decrease in population, increasing, however, in some regions of the one-generation area, notably northern Ohio and Michigan and parts of Ontario and Quebec in Canada. While damage was not as great in 1936 in some sections of the two-generation area as in the previous year or two, the losses there have been large and the borer continues as a pest of prime importance.

Establishment of the borer to the south continues to be slow. This fact seems to corroborate the zonation studies, discussed later, which indicate a transition zone between the one and two-generation areas, in which the one-generation borer may not increase as rapidly and through which the spread may be slow. However, once the borer passes the transition zone into a definite and favorable two-generation area, it would appear that a more rapid increase and spread to the south and west may be expected.

Briefly, the situation must still be considered as a nationally serious problem. For the safety of future agriculture and as inexpensive insurance for our most valuable crop, the several lines of research must be continued as later recommended.

Results of last season. As already stated, the research of the last season has fol-

lowed closely the recommendations made by this committee a year ago. The results, here briefly stated, are notable and provide a substantial addition to our knowledge of the insect and of control practices.

The zonation studies have been developed to the degree that publication of the results and conclusions is desirable. A manuscript dealing with this subject has been prepared for publication by the Bureau of Entomology and Plant Quarantine. These studies, based on the stabilized conditions in Europe and the Orient, and weather station records in the United States, indicate areas of one, two and three-brooded borers in America, and also the presence of transition zones, the latter indicating the possibility of areas where the borer is least likely to increase and spread rapidly and, therefore, least likely to be a serious pest. This may explain the slow progress of the borer southward through the transition zones of the central west.

Studies of the natural enemies of the borer in Europe and Japan have been responsible for the importation of 24 species of insect parasites. Liberations in the states have shown great promise for two of these species, *Inareolata punctoria* and *Lydella stabulans* var. *griescens*. One of these has been distributed over the major infested areas and the second will have been liberated over the same area by the end of the 1937 season. In Canada *I. punctoria* and another species, *Chelonus annulipes*, have shown promise. As might be expected the parasite establishment work has been slow but consistent, and the recovery studies emphasize the permanent value of biological control.

The corn varietal studies of 1936 have demonstrated very definitely the future value of strains which will provide resistant and tolerant qualities toward the corn borer. It is only a matter of time until the practical use of such desirable strains is a reality. Especial importance is given this method of protecting the corn crop from the borer because it will provide a means of control which the individual farmer can adopt without regard for the action of his neighbors.

The insecticide studies have been continued. Among the materials which have shown outstanding efficiency are derris, nicotine tannate and phenothiazine. The studies have provided information of fundamental value in insecticide investigations in general, in addition to the direct application to corn borer control in sweet corn and dahlias.

The infestation and survey studies have been continued in as far as they are essential to the conduct of the major research projects. In this connection, studies on the borer as a potato pest, in that part of the territory where two generations occur, indicate a tendency for potato infestations to build up and the possibility that it will become a serious potato pest, especially in the southern regions of infestation.

Recommendations.—(1) Infestation and survey studies should be continued and enlarged, if necessary, to aid in interpreting changes in borer abundance on the basis of seasonal weather conditions in different regions, to provide the information so essential in the locating and timing of parasite releases in the field, and in the application and interpretation of insecticidal or other control practices. State organizations, not already cooperating in maintaining the survey, are urged to provide means to assist the federal survey and to keep in close touch with borer increase and abundance.

(2) Distribution of one species of parasite over the major infested area and the proposed completion of the distribution of a second species over the same area in 1937 have been reported. Further study should be given other species locally established, as they may apply to particular areas in the United States and Canada. Also, further exploration of sources of parasites from abroad should be made.

(3) The outstanding developments in varietal resistance and tolerance in corn warrant a continuation of the work in the central west. It would be highly desirable to have similar work promoted in Canada and the results of the experiments in the central west demonstrated in new territory, particularly under eastern conditions.

Although it is recognized that the development of resistant and tolerant corn varieties is based on a deep understanding of insect physiology and ecology, we recognize the necessity for the continued support and cooperation of plant breeders and urge even closer association of these two sciences in the plant breeding work, and if possible, the assignment of a plant breeder at the Toledo laboratory to cooperate with the entomologists in the plant resistance studies.

(4) The committee urges immediate publication of the results of zonation studies and the annual publication of seasonal results, in the form of bulletins, particularly the relation of infestation and seasonal conditions, and summarization of planting date studies.

(5) The insecticide studies, which have produced so much of value in the fundamentals

of insecticides should be continued and the results to date applied in different environmental regions.

(6) While this report has referred primarily to the investigations of the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture, your committee recognizes the valuable research in progress in Canada and in several of the states, notably Connecticut, New Jersey, Virginia, Massachusetts, Ohio and Indiana, and urges its continuation.

J. J. DAVIS, *Chairman*
A. B. BAIRD
G. A. DEAN
L. CAESAR
D. J. CAFFREY

[J. J. Davis moved acceptance of the report and the discharge of the committee. This matter was discussed at considerable length and finally the motion was put to a vote and carried.]

CROP PROTECTION INSTITUTE

Plan and Progress of Work, 1936

In the calendar year 1936 the Institute has maintained a total of 16 projects, including exploratory or preliminary studies as well as major, full-time projects. Work has been in progress in 17 states as follows: California, Colorado, Delaware, Illinois, Indiana, Iowa, Louisiana, Maryland, Massachusetts, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, South Carolina and Virginia.

The total number of research men employed, either on a full-time basis or part time, has been 18, of whom eight have been engaged in work relating largely to entomology, nine on problems in plant pathology or plant nutrition, and one on problems of animal diseases.

Research appropriations provided by manufacturers and handled through the Institute in the course of the year have totaled $53,735.

The following projects were administered.

New copper fungicides.—This is a continuation of the 1935 project, in which a new colloidal copper compound has been developed and received extensive field tests. The new material is now in semicommercial production and has been given the name *Z-O*. It is a finely divided material, available in dry form, and has a copper content of approximately 25 per cent. It has been used successfully at concentrations ranging from one-half pound to 1½ pounds per 100 gallons of water. It is relatively safe on plant foliage as compared with other copper compounds. The work is supported by the Nichols Copper Company. Chairman of the Institute committee is Dr. J. F. Adams. A. A. Nikitin is employed full time on this project.

Copper in plant nutrition.—This work is a continuation and expansion of the similar work of 1935. Dr. Thomas F. Manns is chairman of the Institute committee, and the funds are supplied by the Nichols Copper Company. Walter L. Churchman and Marshall Manns have been employed full time. Extensive field plots in several eastern states have again demonstrated the fact that copper sulfate, when added to commercial fertilizer at the rate of 50 pounds to the ton of fertilizer, is capable of bringing about not only increased crop production but higher quality. In a series of field plots tobacco showed a marked increase in yield in 11 out of 12 localities. The increase ranged from 11 to 101 per cent. In addition, tobacco from these plots commanded a premium when sold at auction, in competition with tobacco which had not received fertilizer containing copper sulfate. Tobacco from copper plots shows an increased "body," which is desired by growers and buyers. The average increase in value of the tobacco from copper plots was 37 per cent.

Twelve plots of cotton which received copper in the fertilizer showed an increased yield ranging from 3 to 62 per cent. The average increase was 21 per cent. The presence of copper tends to increase both the number and size of bolls per plant.

A field plot of sweet corn showed an increase of 9 per cent where copper was present in the fertilizer.

Detailed studies were made as to soil flora and the copper content of plants, with the intent of discovering the underlying causes for the increases recorded.

Pyrethrum growing.—This work, which has been in progress for a period of years, was brought to a close in September 1936. A very large amount of data on pyrethrum was accumulated. Farm plantings were maintained. Problems relating to disease control, cultural requirements, fertilizer requirements and the like, were worked out. In cooperation

with the U. S. Department of Agriculture, progress was made in the development of special harvesting machinery.

The chairman of the Institute committee was Dr. T. J. Headlee. Funds were supplied by Stanco, Incorporated. Raymond E. Culbertson was employed full time as a member of the Institute research staff.

Synthetic organic compounds.—In this project, continued from 1935 and somewhat expanded, the Institute, in cooperation with the research department of the Monsanto Chemical Company, explored the insecticidal and fungicidal possibilities of various synthetic organic compounds prepared in the Monsanto laboratory. New substances which have given promise are under test. The compounds so far developed are principally of use as contact insecticides, but at least one new material shows promise as a fungicide. W. P. Flint is chairman of the Institute committee, with Dr. H. W. Anderson in charge of the fungicide studies. Dr. C. W. Kearns is employed full time in the insecticide work and S. L. Hopperstead has been employed part time in the fungicide investigations.

Synthetic organic compounds as insecticides.—This is a further investigation of a long series of new organic compounds originating in the laboratories of the Dow Chemical Company. Dr. C. H. Richardson is chairman of the Institute committee, and Dr. J. Franklin Kagy is employed as full time investigator, with temporary assistance from time to time. Approximately 100 new compounds have been under test, of which the most outstanding is dinitro-ortho-cyclohexyl-phenol, which has been found to have a toxicity as a stomach poison considerably greater than that of lead arsenate. Other materials also show promise.

New fungicides.—Beginning in April 1936, the Institute undertook a preliminary program for the National Aniline Company, to explore the fungicidal activities of several compounds originating in the research laboratories of that company. Dr. J. F. Adams is chairman of the Institute committee, and John W. Heuberger has been employed full time. The studies have indicated interesting possibilities. Control of some plant diseases has been secured with an unusually high margin of safety to the host plants.

Control of codling moth.—This work follows a similar project of 1935. Professor J. J. Davis is chairman of the Institute committee. J. M. Amos is employed full time. Extensive field plots were maintained in Indiana, with supplementary plot work in Maryland, Colorado, New York and Massachusetts. Data have been secured on substitutes for lead arsenate, and good results have been obtained with basic zinc arsenate as a late season spray, following applications of lead arsenate in the early season. Supported by General Chemical Company.

Calcium arsenate investigations.—In cooperation with the research laboratories of the General Chemical Company, the Institute is making detailed studies of the performance of calcium arsenates. Dr. C. O. Eddy is collaborating with the Institute in direction of this work.

Miscellaneous insecticide and fungicide studies.—In this project various exploratory studies are under way for the General Chemical Company. These investigations are conducted in several localities.

Control of disease on seedlings.—A preliminary project was maintained through a part of 1936 with funds supplied by the Metals Refining Company, under the direction of Dr. H. W. Anderson. Dr. K. J. Kadow was employed part time. The investigation has yielded information of value on the performance of cuprous oxide in control of damping off and other diseases.

Cuprous oxide.—Continuing the work of 1935 the Institute has maintained further extensive studies of *Cuprocide*, manufactured by the Rohm and Haas Company. The chairman of the Institute committee is Dr. J. G. Horsfall, with the cooperation of Dr. Otto A. Reinking. Dr. R. O. Magie was employed during the first part of 1936, with Dr. R. F. Suit succeeding him. Laboratory and greenhouse studies have been supplemented by field applications, both as a control of seedborne diseases and as a spray on hops, tomatoes and tree fruits. Important information has been obtained.

Pyrethrum and nicotine sprays.—These investigations, known as the "DX Project," are concerned with the performance of various toxicants, including pyrethrins, nicotine, and synthetic compounds, in a spray material termed the "DX Base." Studies have included a large amount of laboratory work, together with field plots in several localities, especially Maryland, Indiana and Colorado, and with supplementary work in other states. Dr. W. C. O'Kane is chairman of the Institute committee. G. L. Walker and William H. O'Kane were employed full time.

Spreading and wetting agents.—Preliminary work has been done on spreading and wetting agents supplied by General Dyestuff Corporation. Results have been encouraging and further exploration is in progress.

Iodine compounds—This is a preliminary project, maintained as part-time work through a part of 1936 with funds supplied by Amino Products Company. The work consisted of laboratory studies carried out under the supervision of Dr. William H. Martin, with Francis R. Lancaster employed as part-time investigator.

Control of coccidiosis.—This is a short-time exploratory project carried out under the direction of Dr. E. R. Becker, with Dr. N. F. Morehouse employed through the summer season. Work was financed by Rare Chemicals, Inc., and the intent was to ascertain the possibilities of controlling coccidiosis of chicks through administration of a compound known as *Azamine*.

New insecticides from France.—This is a preliminary study to determine the possibilities of several materials originating in France and imported by Standard Chemical Products, Inc. W. A. Westgate has been employed part time. Interesting results have been secured, especially in the direction of ovicides for such insects as the tent caterpillar, gipsy moth and European red mite.

Bulletins.—Bulletins issued in 1936 in the C.P.I. series included the following:

No. 52, "Sulfuric Acid for Control of Weeds," by W. E. Ball and O. C. French.

No. 54, "The Rôle of Pine Oil in Cattle Fly Sprays," by Allen M. Pearson.

No. 55, "Copper Sulfate As a Plant Nutrient and Soil Amendment," by W. L. Churchman, R. Russell and T. F. Manns.

No. 56, "The Crop Protection Institute, Its Organization, Plan of Procedure, and Work Accomplished," by W. C. O'Kane.

No. 57, "Ovicidal and Scalecidal Properties of Solutions of Dinitro–o–cyclohexylphenol in Petroleum Oil," by J. Franklin Kagy and Charles H. Richardson.

No. 58, "Toxicity of Some Nitro-Phenols As Stomach Poisons for Several Species of Insects," by J. Franklin Kagy.

No. 59, "Laboratory Method of Comparing the Toxicity of Substances to San Jose Scale," by J. Franklin Kagy.

No. 60, "Halowax (Chlorinated Naphthalene) as an Ovicide for Codling Moth and Oriental Fruit Moth," by E. P. Breakey and A. C. Miller.

[This report was read by Dr. W. C. O'Kane, who moved the acceptance of the report. This was seconded by J. J. Davis, and on discussion it was decided to request Dr. O'Kane to read the report to the general session.]

COMMITTEE TO FORMULATE PLANS FOR INVESTIGATION OF THE CODLING MOTH FROM BIOLOGIC AND CONTROL STANDPOINTS

The Codling Moth Committee has continued to function as in recent years. As usual, arrangements were made with the Bureau of Entomology and Plant Quarantine for the compiling and mimeographing of data resulting from codling moth investigations carried on during 1935. This was circulated during January and February, 1936, among the official entomologists interested, as confidential information in advance of its regular publication. On invitation received from the North Central States Entomologists and from Dr. Carl J. Drake, of Iowa State College, a conference was held at Ames, Iowa, on March 3 and 4. This conference was attended by some 85 entomologists from 20 states. The minutes of the conference were made available to those in attendance and also to a number of interested entomologists who were unable to be present.

The 1936 conference was the third in as many successive years to be held in conjunction with the meetings of the North Central States Entomologists. In order that entomologists in other sections might have a better opportunity to attend these conferences, the Committee has been giving consideration to the possibility of a rotation of such meetings as may seem desirable, among the regions most directly interested in the codling moth problem. As a start in this direction, the committee is therefore sponsoring a conference to be held immediately following the meetings of the parent Association at Atlantic City, probably on the afternoon of December 31 and continuing through January 1, 1937.

In preparation for this conference the Bureau of Entomology and Plant Quarantine has, at the request of your committee, arranged for the compiling of the usual pool of 1936 codling moth results. This has been done a little earlier than usual. The portion contributed by state workers, the Entomological Branch of the Canadian Department of Agriculture, and the Crop Protection Institute, was mailed to official entomologists on December 19.

Reports received later will be included in a supplement. The contribution of the results of the work of the Bureau of Entomology and Plant Quarantine will be made available to interested entomologists at the time of the conference, and will shortly be mailed to those workers who are unable to attend. The Bureau will also record and distribute the proceedings of the conference.

The designation under which this committee has been known: "Committee to Formulate Plans for Investigation of the Codling Moth from Biologic and Control Standpoints," is extremely cumbersome and not especially appropriate. Your committee, therefore, recommends that this name be changed to the following: Committee on the Codling Moth.

B. A. PORTER, *Chairman*
J. S. HOUSER
G. M. LIST
P. J. PARROTT
W. A. ROSS
W. J. SCHOENE

[This report was made by Dr. Porter. The report was accepted and the title of the committee changed to the Committee on the Codling Moth.]

COMMITTEE ON TERMINOLOGY

[This report was passed over due to the absence of Chairman C. M. Smith.]

COMMITTEE ON ADVANCEMENT OF OFFICIAL ENTOMOLOGY

The committee begs to report that during the year it has not had occasion to take any action of significance. The committee feels, however, that in all probability there will be opportunity for work by such a committee in connection with the shift from emergency to regular funds and therefore desires to recommend the continuation of the committee.

It was apparently intended last year that this committee be made a revolving committee to serve for both entomological organizations and the committee recommends that the nominating committee be requested to set up the committee in this manner for this year.

E. F. PHILLIPS, *Chairman*
THOMAS J. HEADLEE
W. P. FLINT

[Dr. Phillips moved the acceptance of the report. Seconded by Dr. Headlee. Carried.]

COMMITTEE ON POPULAR ENTOMOLOGICAL EDUCATION

Your committee inaugurated its work by circularizing the entomologists in the Association requesting that they put forth a special effort to release through the press, radio, exhibits and other avenues as much entomological information as possible and that they attempt to ascertain through press clippings the extent to which this work gained recognition. The response of the membership was gratifying.

From 504 newspapers we had clippings of 31,600 inches, roughly 200 pages of newspaper material. Inasmuch as there are over 10,000 newspapers in the United States, which are probably carrying commensurate material, there are in all 20 times this quantity of material, or 4000 pages of newspaper material occurring annually on insect subjects.

Of the 500 papers from which we received clippings approximately 100 are dailies, 300 weeklies and 200 bimonthlies. That means roughly 50,000 editions of an average of 6 pages each, or 300,000 pages of news material of which entomology was one two-thousandth of a page per edition, about one line.

This is not nearly enough. But it is not as small amount as it would appear. It must be remembered that if we get one line per edition in a daily this means that about once a week we get an inch item, or once a month a 4-inch write-up. It must also be remembered that a large part of space in the magazines and newspapers is taken up with advertising and immediate news of the territory covered by the paper. I believe that our science probably commands as much or more space in the newspapers as any other field of non-news activity.

Among the clippings used in this survey the large majority were published anonymously and it was difficult to determine the source of information. Where the source was definitely given we found that the federal Department of Agriculture was credited with 204 of the

clippings, amounting to 1908 inches of column space. The state agricultural colleges were credited with 123 of the clippings, 1148 inches of space; the state departments of agriculture were credited with 31 of the clippings covering 295 inches of space; the Associated Press, United Press, International News Service and other syndicated agencies were credited with 37 articles and 233 inches of space. The remaining credited articles were written by science and feature writers, for the most part staff members of the papers concerned.

The subjects covered by these various articles are shown in the accompanying tabulation.

SPECIFIC ARTICLES

Subject	No. Inches	Subject	No. Inches
Screwworm	13,700	Termites	207
Black stem rust	4,600	Quarantines	205
Grasshoppers	1,607	Boll weevil	190
Periodical cicada	912	Cotton flea hopper	177
Codling moth	787	Gypsy moth	177
Tent caterpillar	408	Cotton leaf worm	167
House ants	316	Earwigs	148
Parasite	293	Beekeeping	143
Dutch elm disease	257	Artichoke plume moth	119
Insecticides	250	Autogryro and airplane	116
Mosquitoes	239	Chinch bug	108
Black widow spider	213	Losses by insects	102

In addition to the above, a survey carried on by the Entomological Branch of the Department of Agriculture of Canada, in which 6655 clippings were reviewed, showed 38,600 inches of material on entomological subjects. Of these, there were 863 articles on grasshoppers, 65 on the black widow spider, 62 on potato insects, and 363 on the European corn borer. The remainder covered a wide variety of subjects. Much of this material was the result of publicity work originating in the Department, which involved the release of 573 inches of press material.

Other avenues of publicity which have been rapidly forging to the front are the radio and motion pictures. The motion picture has, of course, done comparatively little in publicizing entomology compared with what could be done in this field. The radio, on the other hand, has done a great deal.

Your committee suggests that its members take a more active interest in seeing that entomological matters receive due recognition in the public press. We should therefore suggest, first, that those connected with agricultural experiment stations and colleges furnish adequate material to the publicity service usually associated with the extension department of the college, and second, that all entomologists contact the science writers of the large city papers. These writers are particularly qualified to write articles in a way that will be scientifically acceptable and that will also make a popular appeal to insure their being read by the subscribers of the paper. It has been found by the federal Department of Agriculture that the laying out of a program for news releases and preparing them at regular stated intervals covering timely subjects insures this work against being overlooked. We recommend that radio broadcasting be materially increased and suggest that our members whenever possible contact the officials of the radio broadcasting stations and arrange for a regular program of timely entomological talks. Wherever this has been done the material has been very popular with the radio broadcasting people. We further suggest that at all stage and county fairs the entomologists see to it that their subjects be adequately represented.

J. A. Hyslop, *Chairman*
E. O. Essig
J. J. Davis

[Mr. Hyslop presented this report and moved its acceptance. The motion was seconded by J. J. Davis, and carried.]

COMMITTEE ON PUBLICATION OF INDEX V

[In the absence of Dr. Felt, Miss Colcord informally discussed the work of this committee.]

LEONARD S. MCLAINE, *President of the Association and Chairman of the Executive Committee.*—12-28-36.

REPORT OF THE RESOLUTIONS COMMITTEE

The committee recommends adoption of the following:

RESOLVED, That the American Association of Economic Entomologists membership sincerely appreciates the presence and participation at this meeting of our esteemed leader, Dr. L. O. Howard, and hereby records this appreciation with our best wishes for his happiness and good health.

RESOLVED, That we express to the committee on local arrangements, T. J. Headlee and C. H. Hadley, our appreciation and thanks for the excellent arrangements made by them for our comfort and entertainment during this meeting.

RESOLVED, That we express to the management of Haddon Hall our appreciation of the ideal facilities provided for our meeting and that the Secretary be instructed to transmit our thanks to the Manager.

RESOLVED, That the American Association of Economic Entomologists desires to express to the officers and members of The Entomological Society of America our appreciation of the continuing cooperation of the two organizations in the joint meetings annually arranged and to express the further hope of increasing cooperation between the two organizations.

RESOLVED, That we authorize the Secretary to send felicitations to Professor Herbert Osborn and to express our regrets at his absence from our 1936 meeting, the first meeting which he has missed in 35 years.

RESOLVED, That we express our thanks to Lee A. Strong, Chief of the Bureau of Entomology and Plant Quarantine, for making the Presidential Addresses of this Association so readily available to our membership.

WHEREAS, Outbreaks of seriously injurious insects and plant diseases may appear suddenly and unexpectedly and at times when relief by appropriations would be impossible because the Congress is not in session, therefore, be it

RESOLVED, That the American Association of Economic Entomologists expresses the opinion that it would be wise and in accord with the public welfare if the Congress would make financial arrangements so that, with suitable and appropriate safeguards, the attack on any such pest could be undertaken immediately at the outset.

RESOLVED, That the Committee on the Promotion of Official Entomology be hereafter designated as the Joint Committee on the Promotion of Official Entomology in order to indicate cooperation between the two entomological organizations.

E. F. PHILLIPS, *Chairman*
S. E. FLANDERS
G. M. BENTLEY
A. G. RUGGLES

REPORT OF THE SPECIAL COMMITTEE ON AMENDMENTS TO THE CONSTITUTION AND BY-LAWS

Your committee, which was appointed to consider and report on the draft of a revised Constitution and By-Laws of this Association, has carefully considered this matter and begs leave to submit the following recommendations:

(1) That in view of the short time that has been available for the membership to study carefully the proposals made, that this draft be referred back to the Executive Committee for further study and the preparation of a redraft.

(2) That a copy of said redraft with the reasons for making the changes from the present

Constitution and By-Laws be sent to each active member of the Association on or before July 1, 1937, for his consideration and comments.

(3) That the President-elect appoint a special committee to consider the final redraft and recommendations of the Executive Committee so that a report with recommendations can be submitted to the Association at the next annual meeting.

(4) The committee further recomends that the Executive Committee take up with the national and other entomological societies the resolution approved by the Association at the last annual meeting, viz., "Be it resolved that this Association express its belief in the timeliness and wisdom of efforts now being made and plans under way to bring about a closer bond among all workers in entomology, looking forward to the time when all the various activities, societies, branches and interests may be so related in organization, work and publications as to constitute a substantial unity of aim and effort," in order that steps may be taken to bring about the purposes therein set forth.

A. F. BURGESS, *Chairman*
S. W. BILSING
H. B. HUNGERFORD
A. M. BOYCE
ARTHUR GIBSON

REPORT OF THE COMMITTEE ON MEMBERSHIP

The committee recommends the election of the following 54 persons to active membership.

John Alsterlund, Urbana, Ill.
John M. Amos, Lafayette, Ind.
William H. Anderson, Atlanta, Ga.
John P. Barrett, New York City
Clifford J. Boissonou, Martinez, Calif.
J. C. Bradley, Ithaca, N. Y.
Kenneth E. Brown, New York City
R. C. Brown, New Haven, Conn.
William O. Buettner, Brooklyn, N. Y.
James Harvey Cochran, Ames, Iowa
Harvey James Crawford, Gilmer, Tex.
S. L. Crosthwait, Berlin, Md.
Frank Daybell, Porterville, Calif.
C. Norman Dold, Lafayette, Ind.
Joseph A. Evans, Ithaca, N. Y.
Francis B. Foley, Glendale, Calif.
Louis G. Gemmell, New Brunswick, N. J.
Avery H. Goddin, Newark, Del.
Lewis T. Graham, Baton Rouge, La.
James B. Gross, York, Pa.
S. O. Hill, Albany, Ga.
John D. Hitchcock, Laramie, Wyo.
J. Douglas Hood, Rochester, N. Y.
Adelbert F. Howland, Alhambra, Calif.
Benjamin J. Kaston, New Haven, Conn.
Arthur S. Kidwell, Baltimore, Md.
Alexander E. Lawrance, Vancouver, B. C.
Glen E. Lehker, West Lafayette, Ind.
Clemence Levin, Memphis, Tenn.
Chi-ying Liu, Hangchow, China
William E. McCauley, Urbana, Ill.
T. McGregor, College Station, Tex.
Forrest B. McLane, Montebello, Calif.
Charlie M. Meadows, Baton Rouge, La.
Robert M. Melampy, Baton Rouge, La.
Harry F. Olds, Vancouver, B. C.
Charles R. Page, Columbus, Ohio
Paul Phillips, Gallup, N. M.
Dwight Powell, Urbana, Ill.
Robert A. Ragains, Indianapolis, Ind.
Robert A. Ranck, Baltimore, Md.
Thomas S. Reid, New Brunswick, N. J.
Max Rukin, Chicago, Ill.
Silas S. Sharp, Baton Rouge, La.
Ralph W. Sherman, Bloomfield, N. J.
Sardor Singh, Lyallpur, Punjab, India
Max A. Sisson, Grand Junction, Colo.
B. Thomas Snipes, Ames, Iowa
E. M. Stafford, Ithaca, N. Y.
Albert W. Trippel, Mishawaka, Ind.
R. Edward Trumble, Wenatchee, Wash.
James T. Walker, Geneva, N. Y.
Joseph E. Webb, Jr., Cornelia, Ga.
Cynthia Westcott, Glen Ridge, N. J.

The following person is recommended for foreign membership:
Hachiro Yuasa, Doshisha University, Kyoto, Japan

The committee recommends that Gonzalo Merino, Manila, P. I., be continued as an active member.

[The committee also recommended three members to be continued in active membership without payment of dues.]

C. H. RICHARDSON, *Chairman*
W. P. FLINT
WILLIAM MOORE

REPORT OF SPECIAL COMMITTEE ON COOPERATION WITH NATIONAL PEST CONTROL OPERATORS

The committee appointed by President McLaine to consider closer cooperation with the National Pest Control Operators met with the committee of the latter organization, which consisted of William Buettner, Max Rukin and M. T. Myer. This committee wishes to secure closer cooperation with the American Association of Economic Entomologists. After some discussion as to how this could be brought about, your committee desires to make the following recommendations:

That at the suggestion of the Pest Control Operators Committee, we arrange with them to hold regional conferences on pest control, these courses to be given at various universities and state colleges, arrangements for these courses to be made with the National Pest Control Committee;

That we encourage closer cooperation with the American Association of Economic Entomologists and the National Pest Control Operators;

That a committee of five from the American Association of Economic Entomologists be appointed as a standing committee to work with the Committee from the National Pest Control Operators Association.

W. P. FLINT, *Chairman*
J. G. SANDERS
NEELY TURNER
J. J. DAVIS
ROBERT N. MATHESON
E. A. BACK

REPORT OF ADVISORY COMMITTEE, JOURNAL OF ECONOMIC ENTOMOLOGY

The committee recommends action by the Association upon the following points:

(1) That the officers of the JOURNAL OF ECONOMIC ENTOMOLOGY be commended for the efficient manner in which they have performed their duties during the past year.

(2) That manuscripts submitted for publication in the JOURNAL which have been published previously in their essential form in print or otherwise be refused for republication.

(3) That the Editor is instructed not to supply galley proof and reprints of scientific notes intended for publication in the JOURNAL unless so requested by the author at the time the manuscript is submitted.

WM. A. RILEY, *Chairman pro tem*
ERNEST N. CORY
J. S. HOUSER

REPORT OF ADVISORY COMMITTEE, JOURNAL OF ECONOMIC ENTOMOLOGY, TO NOMINATING COMMITTEE, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The committee recommends that the following persons be nominated to serve as officers of the JOURNAL OF ECONOMIC ENTOMOLOGY for the year 1937.

Editor, T. H. Frison
Associate Editor, H. B. Weiss
Business Manager, Ernest N. Cory
Honorary Editor, E. P. Felt

WM. A. RILEY, *Chairman pro tem*
J. S. HOUSER

REPORT OF NOMINATING COMMITTEE

FIRST REPORT

Committee on Common Names of Insects

J. A. Hyslop, Term expires 1939
R. B. Friend, Term expires 1939
H. B. Hungerford, Term expires 1938
L. M. Peairs, Term expires 1938
H. S. Smith, Term expires 1937
Wm. J. Baerg, Term expires 1937

Committee on Membership

A. F. Satterthwait, Term expires 1939

Advisory Committee, Journal of Economic Entomology

F. L. Campbell, Term expires 1941
F. L. Thomas, Term expires 1941

Joint Committee on Insect Collections

C. F. W. Muesebeck, Term expires 1939
T. H. Frison, Term expires 1939

Councillor for the American Association for the Advancement of Science

Leonard Haseman, Term expires 1938

Trustee for Crop Protection Institute

J. J. Davis, Term expires 1939

Representative on Council of Union of American Biological Societies

W. A. Price
C. L. Metcalf

Representative on Board of Trustees for Tropical Plant Research Foundation

Herbert Osborn

Committee on the Codling Moth

R. L. Webster, Term expires 1939
H. N. Worthley, Term expires 1939

Committee on Insecticide Terminology

Harry F. Dietz, Term expires 1941

Committee on Advancement of Official Entomology

J. J. Davis,[1] Term expires 1939

Committee on Popular Entomological Education

C. J. Drake, Term expires 1939

SECOND REPORT

President

F. C. Bishopp

First Vice President

S. W. Bilsing

Secretary

Ernest N. Cory (*Continued*)

Vice Presidents

E. J. Newcomer, Pacific Slope Branch
W. E. Anderson, Cotton States Branch
H. N. Worthley, Eastern Branch
L. H. Worthley, Section of Plant Quarantine and Inspection
E. J. Anderson, Section of Apiculture
T. H. Parks, Section of Extension

Executive Committee

A. F. Burgess, Term expires 1939

[1] In the first report of the committee, H. J. Quayle was nominated to serve on the Committee on Advancement of Official Entomology. This committee was not designated at that time as a joint committee of The Entomological Society of America and the American Association of Economic Entomologists. The motion was invalid because Dr. Quayle is not a member of the Society, hence in view of these circumstances the committee begs leave to substitute the name of J. J. Davis for that of H. J. Quayle in the original report and to suggest that the Secretary be instructed to make the substitution.

Board of Trustees for Permanent Fund
P. J. Chapman, Term expires 1939

JOURNAL OF ECONOMIC ENTOMOLOGY *Staff*
T. H. Frison, Editor
Harry B. Weiss, Associate Editor
Ernest N. Cory, Business Manager
E. P. Felt, Honorary Editor

Program Committee
W. P. Flint, Term expires 1939
D. L. Van Dine, Term expires 1938
P. W. Claassen, Term expires 1937

J. S. HOUSER, *Chairman*
HARRY B. WEISS
CLAY LYLE

[Dr. Bishopp was escorted to the Chair by Dr. Headlee and A. G. Ruggles.]

REMARKS OF F. C. BISHOP UPON ASSUMING THE CHAIR AFTER ELECTION

This action of the Association comes as a great surprise. I think this selection must be credited to a recognition of medical entomology rather than to any special qualifications which I have for the position. I feel deeply the honor and responsibility you have placed on me. With your cooperation and support I shall do my utmost to further the best interests of the Association.

SECTION OF APICULTURE

The Section of Apiculture met at 9:30, December 28, in the Tower Room of Haddon Hall, Atlantic City, New Jersey. Chairman W. J. Nolan presided and gave a paper on the subject "Modified Technic for the Watson Method." Following this, papers on the program were presented. At the conclusion of this part of the program, Sandar Singh gave a short discussion of beekeeping in India.

The nominating committee, consisting of G. M. Bentley and E. L. Chambers, submitted its report. This resulted in the election of the following officers for the ensuing year: Edwin J. Anderson, Chairman, and W. A. Price, Secretary.

SECTION OF PLANT QUARANTINE AND INSPECTION

The Section of Plant Quarantine and Inspection met at 9:30 a.m. December 30, in the Tower room of Chalfonte-Haddon Hall. There were 52 members in attendance. Twenty-two papers were given on the program. L. H. Worthley was elected Chairman and E. L. Chambers Secretary-Treasurer.

Eastern Branch

PROCEEDINGS OF THE EIGHTH ANNUAL MEETING

Hotel McAlpin, New York, N. Y., November 12 and 13, 1936

FIRST BUSINESS SESSION

Thursday, Nov. 12, 1936. 12:30 P.M.

The meeting was called to order by Chairman Philip Garman, who spoke briefly of the value of Branch meetings. Brief talks were given by Mr. Lee A. Strong, Chief of the Bureau of Entomology and Plant Quarantine, by Mr. J. S. Houser, who brought greetings from the North Central States Branch and who complimented the Eastern Branch on

its publication of *Entoma*, and by Dr. Leonard S. McLaine, President of the American Association of Economic Entomologists.

The Chairman appointed the following committees:

Committee on Nominations: E. N. Cory, R. B. Friend, E. P. Felt.
Auditing Committee: J. L. Horsfall, M. P. Zappe.
Committee on Resolutions: T. J. Headlee, S. W. Bromley, P. J. Chapman.

The report of the Secretary-Treasurer was read and referred to the Auditing Committee.

REPORT OF THE SECRETARY-TREASURER

The paying members of the Eastern Branch increased in number from 92 in 1934 to 117 in 1935. Paid membership for the past seven years is shown by the accompanying table.

	1929	1930	1931	1932	1933	1934	1935
West Virginia	1	1	1	2	2	2	3
Virginia	5	4	8	5	4	5	9
District of Columbia	6	3	9	2	5	6	14
Maryland	5	6	9	3	4	5	9
Delaware	2	2	3	1	2	5	5
Pennsylvania	9	3	11	5	15	13	12
New Jersey	26	21	19	11	23	20	23
New York	27	28	39	25	23	25	26
Connecticut	10	9	15	5	6	7	7
Rhode Island	2	0	1	0	0	0	1
Massachusetts	6	5	14	8	4	3	4
Vermont	1	1	0	0	0	0	1
New Hampshire	0	0	1	1	0	0	0
Maine	0	1	2	1	0	1	2
Canadian Provinces	1	0	0	0	0	0	1
TOTAL	101	84	132	69	88	92	117

Sixty-one papers were presented at our 1935 meeting, held at the Southern hotel in Baltimore, November 14 to 15. Except for a few that were withdrawn, these were printed in the 1936 JOURNAL OF ECONOMIC ENTOMOLOGY for February (49.5 pages), April (87 pages), June (84.5 pages), and August (6 pages), occupying a total of 227 pages.

FINANCIAL STATEMENT

Balance on Hand, November 6, 1935		$1,153.95
Receipts		
Additional dues for 1935	$178.00	
Receipts due to sale of Directory space, listings, and sales of Directories	174.79	
Dues for 1936 (to November 2)	58.00	
Total receipts	$410.79	1,564.74
Disbursements		
Lantern and operator, 2 days, Southern Hotel, Baltimore, Md.	30.00	
Stenographic services in connection with Directory	8.50	
Printing program, Baltimore meeting	28.50	
Postage for Directory	10.00	
Postage, Eastern Branch cards, notices	34.50	
Stationery (envelopes) Eastern Branch	6.50	
Clerical services, eastern Branch	10.00	
Refund of an overpayment	2.00	
Bank charge for collecting a $3 Honolulu check	.70	
Total disbursements		130.70
Balance on hand November 2, 1936 (Deposited in Trenton Trust Co.		$1,434.04

HARRY B. WEISS, *Sec'y-Treas.*

The following were elected to affiliated membership:

Dr. B. J. Kaston, Conn. Agricultural Experiment Station, New Haven, Conn.

Mr. J. P. Barrett, Insecticide Department, S. B. Penick Co., 132 Nassau St., New York, N. Y.

FINAL BUSINESS SESSION

Friday, Nov. 13, 1936, 12:30 P.M.

Chairman Garman called for the reports of the following committees. These reports were adopted by the Branch.

REPORT OF THE NOMINATING COMMITTEE

For Chairman, H. N. Worthley
For Vice-Chairman, V. I. Safro

E. N. Cory
R. B. Friend
E. P. Felt

REPORT OF THE AUDITING COMMITTEE

We have audited the accounts of the Secretary-Treasurer and find them to be accurate and in very fine shape.

J. L. Horsfall
M. P. Zappe

Following the adoption of the above report, the report of the Secretary-Treasurer was adopted by the Branch.

REPORT OF THE FINANCE COMMITTEE

The Chairman of your Finance Committee wishes to submit the following report regarding the sale of *Entoma* and receipts for same. This report is independent of the copies of *Entoma* sent out to members of the American Association of Economic Entomologists or members of the Eastern Branch of the American Association of Economic Entomologists and expenses connected with sending out these copies.

Copies of *Entoma* sent out gratis	38			
Cash Receipts				
Copies of *Entoma* sold for 25 cents each	92	$23.00		
Copies of *Entoma* sold 3 for $1.00	71	27.00		
Copies of *Entoma* sold for 50 cents each	104	52.00		
Total cash receipts for *Entoma*			$102.00	
Receipts in Stamps				
Copies of *Entoma* sold for 25 cents each	4	1.00		
Copies of *Entoma* sold 3 for $1.00	3	1.00		
Copies of *Entoma* sold for 50 cents each	28	14.00		
Total receipts in stamps			16.00	
Cash Due				
Copies of *Entoma* sold for 25 cents each	14	3.50		
Copies of *Entoma* sold 3 for $1.00	6	2.00		
Copies of *Entoma* sold for 50 cents each	66	33.00		
Total cash due			38.50	
Grand total				$156.50

Disbursements	
Cash sent to Mr. Weiss	$67.91
Cash used in buying stamps and paying for express	14.02
Cash on hand	20.07
Stamps received in payment for *Entoma*	16.00

Total Disbursements	118.00
Cash due	38.50
Grand total	$156.50

Nov. 9, 1936.

C. C. HAMILTON
A. E. BADERTSCHER
J. L. KING
J. L. HORSFALL
B. A. PORTER
A. WEED
H. B. WEISS

Following the adoption of the above report, the Branch authorized the Finance Committee to proceed with a second edition of *Entoma*, to be published, if possible, during April, 1937.

REPORT OF COMMITTEE ON RESOLUTIONS

WHEREAS, the activities of the Finance Committee of the Branch have undeniably made possible the present satisfactory condition of the Branch treasury, and

WHEREAS such satisfactory condition could easily change to its opposite, now, therefore,

BE IT RESOLVED that the Branch does hereby highly compliment the Finance Committee on its most excellent service and does hereby express the hope that equal or greater success may attend its future efforts.

T. J. HEADLEE
S. W. BROMLEY
P. J. CHAPMAN

The interest and attendance at all sessions were good. The following members and guests registered during the sessions:

Anthony, M. V.
Arnold, R. B.
Badertscher, A. Edison
Baker, Walter C.
Baker, W. L.
Barrett, J. P.
Barry, John J.
Becker, W. B.
Beckwith, C. S.
Birdsall, R. W.
Blanton, F. S.
Blauvelt, W. E.
Blinne, Frederick G.
Bobb, M. L.
Boyd, M.
Brigham, W. Theodore
Britton, W. E.
Bromley, S. W.
Brown, R. C.
Buchanan, W. D.
Buchholz, A. B.
Carruth, L. A.
Chapman, Paul J.
Clement, R. L.
Collins, C. W.
Cory, Ernest N.
Cox, James A.
Craighead, F. C.
Crossman, S. S.
Cunningham, George M.
Darley, M. M.
Daniel, D. M.
Davidson, William
Dean, R. W.
Dewson, I. B.
Dickison, William
Dietz, Harry F.
Ditman, L. V.
Dobroscky, Irene, D.
Dohanian, S. M.
Dorman, Russell
Douglass, A.
Driggers, Byrley G.
Durling, V. B.
Dye, H. W.
Eastman, P. M.
Eaton, N. A., Jr.
Farley, Arthur J.
Felt, E. P.
Fenton, Alfred
Filmer, Robert S.
Freeman, A. F.
French, G. T.
Friend, R. B.
Frost, S. W.
Gambrell, F. L.
Garman, Philip
Geissler, G. H.
Gemmell, Louis G.
Gies, R. W.
Ginsburg, J. M.
Glasgow, Hugh
Glasgow, Robert D.
Goddin, A. H.
Goodhue, Lyle D.
Grannett, Philip
Guy, H. G.
Guyton, T. L.
Gwin, C. M.
Hamilton, Clyde C.
Hamilton, D. W.
Hammer, O. H.
Harman, S. W.
Hartzell, Albert
Hartzell, F. Z.
Hatcher, R. F.
Headlee, T. J.
Heal, Ralph E.
Hess, A. D.
Hoffman, C. H.
Holbrook, R.
Horsfall, J. L.
Houser, J. S.
Huckett, H. C.
Jennings, E. R.
Jobbins, D. M.
Johnson, J. Peter

Jones, M. P.
Karr, Errol Hay
Kaston, B. J.
Kelsheimer, E. G.
King, J. L.
Kisliuk, Max, Jr.
Long, John C.
Lannon, Alvin J.
Lathrop, F. H.
Langford, George S.
MacAloney, H. J.
MacAndrews, A. H.
MacCreary, Donald
MacLeod, G. F.
Markwood, L. N.
Maxwell, Kenneth E.
Maughan, Frank B.
McConnell, H. S.
McLaine, L. C.
Menusan, H., Jr.
Moore, Warren
Moore, Joseph B.
Moore, William
Morrill, Austin W., Jr.
Muirhead, Donald C.
Nelson, Franklin C.
Neumann, G.
Noble, Harold
Nottingham, J. O.
Pepper, B. B.
Plumb, Geo. H.
Poos, F. W.
Porter, B. A.
Potts, S. F.
Powers, George C.
Osborn, H. T.
Rawlins, W. A.
Readio, P. A.
Reed, T. Walter
Reid, Thomas S.
Rex, Edgar G.
Rice, Paul L.
Roark, R. C.
Rohwer, S. W.
Rosen, S. S.
Russell, Raymond
Safro, V. I.
St. George, R. A.
Sameth, Irving
Sanders, George E.
Sanders, J. G.
Schaffner, J. V., Jr.
Schread, J. C.
Shaw, P. M.
Shaw, Frank R.
Sherman, R. W.
Simpson, Geddes W.
Smith, C. R.
Soraci, F. A.
Stearns, L. A.
Stene, A. E.
Steiner, Harold M.
Stocks, J. A.
Strong, L. A.
Tappin, John L.
Tischler, Nathaniel
Tisdale, W. H.
Townsend, J. F.
Tompkins, L. E.
Thomas, W. W.
Thompson, Friar M., Jr.
Turner, Neeley
Underhill, G. W.
Vreeland, C. D.
Wade, Joseph S.
Walker, Harry G.
Walker, James T.
Weed, Alfred
Weigel, C. A.
Weiss, Harry B.
Whall, Harry H.
White, W. H.
Whitten, R. R.
Willey, C. R.
Wood, H. J.
Worthley, H. N.
Worthley, L. H.
Zappe, M. P.

OFFICIAL ROSTER

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

[Organized 1889, Incorporated Dec. 29, 1913]

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Washington, D. C.
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S. W. Bilsing
College Station, Tex.
First Vice President

Ernest N. Cory
College Park, Md.
Secretary

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W. E. Anderson, Baton Rouge, La. (Cotton States Branch)
H. N. Worthley, State College, Pa. (Eastern Branch)
L. H. Worthley, Bloomfield, N. J. (Plant Quarantine & Inspection)
E. J. Anderson, State College, Pa. (Apiculture)
T. H. Parks, Columbus, Ohio (Extension)

BRANCH AND SECTION SECRETARIES

J. L. Lamiman, Davis, Calif. (Pacific Slope Branch)
O. I. Snapp, Fort Valley, Ga. (Cotton States Branch)
H. B. Weiss, Trenton, N. J. (Eastern Branch)
E. L. Chambers, Madison, Wis. (Plant Quarantine and Inspection)
W. A. Price, Lexington, Ky. (Apiculture)
L. H. Shropshire, Des Plaines, Ill. (Extension)

STANDING COMMITTTES

Executive Committee.—F. C. Bishopp, Washington, D. C. *Chairman. Ex officio.*
Ernest N. Cory, College Park, Md. *Ex officio.*
T. J. Headlee, New Brunswick, N. J. Term expires 1937.
J. R. Parker, Bozeman, Mont. Term expires 1937.
L. A. Strong, Washington, D. C. Term expires 1938.
L. S. McLaine, Ottawa, Can. Term expires 1939.
A. F. Burgess, Greenfield, Mass. Term expires 1939.

Committee on Common Names of Insects.—J. A. Hyslop, Washington, D. C. *Chairman.* Term expires 1939.
R. B. Friend, New Haven, Conn. Term expires 1939.
H. B. Hungerford, Lawrence, Kan. Term expires 1938.
L. M. Peairs, Morgantown, W. Va. Term expires 1938.
H. S. Smith, Riverside, Calif. Term expires 1937.
William J. Baerg, Fayetteville, Ark. Term expires 1937.

Committee on Membership.—William Moore, New York, N. Y., *Chairman*
A. F. Satterthwait, Urbana, Ill. Term expires 1939.
C. H. Richardson, Ames, Iowa. Term expires 1939.

Advisory Committee, Journal of Economic Entomology.—W. B. Herms, Berkeley, Calif., *Chairman.* Term expires 1940.
G. M. List, Fort Collins, Colo. Term expires 1937.
W. A. Riley, St. Paul, Minn. Term expires 1937.
Roger B. Friend, New Haven, Conn. Term expires 1938.
J. S. Houser, Wooster, Ohio. Term expires 1938.
H. G. Crawford, Ottawa, Can. Term expires 1939.
Roger C. Smith, Manhattan, Kan. Term expires 1939.
S. A. Rohwer, Washington, D. C. Term expires 1940.
F. L. Campbell, Columbus, Ohio. Term expires 1941.
F. L. Thomas, College Station, Tex. Term expires 1941.

Joint Committee on Insect Collections.—C. F. W. Muesebeck, Washington, D. C. *Chairman.* Term expires 1939.
H. H. Knight, Ames, Iowa. Term expires 1937.
Frank E. Lutz, New York, N. Y. Term expires 1937.
W. J. Brown, Ottawa, Can. Term expires 1938.
E. C. Van Dyke, Berkeley, Calif. Term expires 1938.
C. P. Alexander, Amherst, Mass. Term expires 1938.
Josef Knull, Columbus, Ohio. Term expires 1939.
T. H. Frison, Urbana, Ill. Term expires 1939.

Board of Trustees for Permanent Fund.—Ernest N. Cory, College Park, Md., *Chairman. Ex officio.*
A. F. Burgess, Greenfield, Mass. Term expires 1938.
Leonard S. McLaine, Ottawa, Can. Term expires 1937.
P. J. Chapman, Geneva, N. Y. Term expires 1939.

Representative to National Research Council.
S. A. Rohwer, Washington, D. C. Term expires 1937.
R. W. Leiby, Raleigh, N. C. Alternate. Term expires 1937.

Councillors for the American Association for the Advancement of Science.
Alvah Peterson, Columbus, Ohio. Term expires 1937.
Leonard Haseman, Columbia, Mo. Term expires 1938.

Trustees for Crop Protection Institute.
C. H. Richardson, Ames, Iowa. Term expires 1937.
W. C. O'Kane, Durham, N. H. Term expires 1938.
J. J. Davis, Lafayette, Ind. Term expires 1939.

Program Committee.

W. P. FLINT, Urbana, Ill. Term expires 1939.
D. L. VAN DINE, Washington, D. C. Term expires 1938.
P. W. CLAASSEN, Itahca, N. Y. Term expires 1937.

Representatives on Council of Union of American Biological Societies.

W. A. PRICE, Lexington, Ky.
C. L. METCALF, Urbana, Ill.

Representative on Board of Trustees of Tropical Plant Research Foundation.

HERBERT OSBORN, Columbus, Ohio.

Committee on the Codling Moth.—B. A. PORTER, Washington, D. C., *Chairman*. Term expires 1937.

J. S. HOUSER, Wooster, Ohio. Term expires 1937.
P. J. PARROT, Geneva, N. Y. Term expires 1938.
W. A. ROSS, Vineland Station, Ont., Can. Term expires 1938.
R. L. WEBSTER, Pullman, Wash. Term expires 1939.
H. N. WORTHLEY, State College, Pa. Term expires 1939.

Committee on Insecticide Terminology.—C. M. SMITH, Washington, D. C. *Chairman*. Term expires 1940.

M. D. FARRAR, Urbana, Ill. Term expires 1937.
R. H. ROBINSON, Corvallis, Oregon. Term expires 1938.
WILLIAM MOORE, New York N. Y. Term expires 1939.
HARRY F. DIETZ, Cleveland, Ohio. Term expires 1941.

Joint Committee on the Promotion of Official Entomology.—E. F. PHILLIPS, Ithaca, N. Y. *Chairman*. Term expires 1938.

T. J. HEADLEE. New Brunswick, N. J. Term expires 1937.
J. J. DAVIS, Lafayette, Ind. Term expires 1939.

Committee on Popular Entomological Education.—J. A. HYSLOP, Washington, D. C. *Chairman*. Term expires 1938.

E. O. ESSIG, Berkeley, Calif. Term expires 1937.
C. J. DRAKE, Ames, Iowa. Term expires 1939.

Journal of Economic Entomology Staff.

T. H. FRISON, Urbana, Ill., *Editor*.
E. P. FELT, Stamford, Conn., *Honorary Editor*.
HARRY B. WEISS, Trenton, N. J., *Associate Editor*.
ERNEST N. CORY, College Park, Md., *Business Manager*.

LIST OF MEMBERS

* Life Members ** Members Who Attended 1936 Meeting

ACTIVE MEMBERS

Aamodt, T. L., University Farm, St. Paul, Minn.
Abbott, W. S., Silver Spring, Md.
Ackerman, A. J., 6 West Sycamore St., Vincennes, Ind.
Adair, H. S., Adair's Insect Control Service, Montgomery, Ala.
Adams, J. A., Iowa State College, Ames, Iowa.
Ainslee, C. N., 5009 Orleans Ave., Sioux City, Iowa.
Alden, C. H., State Board of Ent., Cornelia, Ga.
Alexander, Chas. P., Massachusetts State College, Amherst, Mass.
Allen, H. W., Box H, Moorestown, N.J.**
Allen, Norman, Pee Dee Experiment Station, Florence, S.C.
Allen, Paul B., Jr., 1026 North Seventh St., Allentown, Pa.
Allen, R. H., Board of Agr., State House, Boston, Mass.
Allen, Thos. C., Dept. of Ent., University of Wisconsin, Madison, Wis.
Alsterlund, John 205 Floriculture Bldg., Urbana, Ill.

Amos, John M., 2416 East Main St., Lafayette, Ind.**
Anderson, Edwin J., Pennsylvania State College, State College, Pa.
Anderson, L. D., Truck Experiment Station, Norfolk, Va.**
Anderson, O. G., Tobacco By-Products Chemical Corp., Louisville, Ky.
Anderson, William E., Dept. of Agr. & Immigration, Baton Rouge, La.
Anderson, Wm., H., 313 Ten Forsyth St., Atlanta Ga.
Andre, Floyd, Science Bldg., Iowa State College, Ames, Iowa.
Annand, P. N., B.E.P.Q., Washington, D. C.**
Anthon, Edw. W., Utah State Agr. College, Logan, Utah.
Anthony, M. V., 61 Mohican Park Ave., Dobbs Ferry, N. Y.**
Arant, F. S., Auburn, Ala.
Armitage, H. M., Room 24, Agr. Bldg., Embarcadero at Mission St., San Francisco, Calif.
Arnold, George F., State College, Miss.
Arnold, Robert B., Tobacco By-Products Chemical Corp., Richmond, Va.**
Ashworth, John T., Danielson, Conn.
Au, S., Box 3319, Board of Agr., Honolulu, T. H.
Audant, Andre, S.N.P.A., Port Au Prince, Haiti.
Avery, Paul C., Mission, Tex.

Babcock, O. G., Box 407, Sonora, Tex.
Back, E. A., B.E.P.Q., Washington, D. C.**
Badertscher, Amos E., 2824 Overland Ave., Baltimore, Md.
Baerg, Wm. J., Fayetteville, Ark.
Bailey, H. L., Dept. of Agr., Montpelier, Vt.**
Bailey, J. L., Box 283, Greenfield, Mass.
Bailey, John W., Richmond University, Richmond, Va.
Bailey, Stanley F., University Farm, Davis, Calif.
Baird, Alfred Briggs, 228 Dundas St. E., Belleville, Ont.
Baker, Arthur C., Laboratory of Entomology, Calzada Tacuba 295, Colonia Anahuac Mexico, D. F.**
Baker, A. W., Ontario Agr. College, Guelph, Ont., Can.
Baker, Howard, Box 424, St. Joseph, Mo.**
Baker, Wm. A., 1920 Parkwood Ave., Toledo, Ohio.
Baker, W. C., 8 Whippany Road., Morristown, N. J.**
Baker, Wm. W., Box 233, Puyallup, Wash.
Balduf, W. V., 610 Michigan Ave., Urbana, Ill.
Ball, E. D., Agr. Experiment Station, University of Arizona, Tuscon, Ariz.
Ballou, Charles H., Apartado 1368, San José, Costa Rica.
Balzer, August I., Box 2967, Beaumont, Tex.
Barber, E. R., 1200 South Broad St., New Orleans, La.
Barber, H. S., U. S. National Museum, Washington, D. C.
Bare, Clarence O., R.F.D. 4, Box 17, Charleston, S. C.
Bare, Orlando S., 2325 North 67th St., Lincoln, Neb.
Barnes, D. F., 712 Elizabeth St., Fresno, Calif.
Barnes, Olus L., B.E.P.Q., Tempe, Ariz.
Barnes, Parker T. R.F.D. 2, Hummelstown, Pa.
Barrett, John P., S. B. Penick & Co., New York, N. Y.
Barrett, Ralph E., Box 171, Saticoy, Calif.
Barrett, W. L., Jr., Box 509 Uvalde, Tex.
Bartlett, Irene L., Room 375, U. S. National Museum, Washington, D. C.
Bartlett, Kenneth A., 10 Court St., Arlington, Mass.
Bartlett, O. C., 2211 West Washington St., Phoenix, Ariz.
Bartley, H. N., Fourth Floor, Custom House, Boston, Mass.
Basinger, A. J., Citrus Experiment Station, Riverside, Calif.
Batchelder, C. H. 91 Wakefield St., Hamden, Conn.**
Baumhofer, L. G., U. S. Forest Insect Laboratory, Fort Collins, Colo.**
Beal, James A., Forest Insect Laboratory, Fort Collins, Colo.**
Becker, G. G., B.E.P.Q., Washington. D. C.
Becker, William B., Fernald Hall, Massachusetts State College, Amherst, Mass.
Beckwith, Charles S., Cranberry Experiment Station, Pemberton, N. J.**
Bedard, Wm. Delles, Forest Insect Field Station, Coeur d'Alene, Idaho.

Bedford, Theodore, Wellcome Research Laboratory , Khartoum, Sudan.
Ben-Amotz, Yehiam, 2440 Dwight Way, Berkeley, Calif.
Bentley, G. M., State Entomologist, Knoxville, Tenn.**
Benton, Curtis, Box 495, B.E.P.Q., West Lafayette, Ind.
Bergen, Harold C., University of Idaho, Moscow, Idaho.
Berger, E. W., 2877 University Station, State Plant Board, Gainesville, Fla.
Berly, J. A., Clemson College, S. C.
Berman, H. D., 227 North First St., Minneapolis, Minn.
Berry, N. O., 503 Rio Grande Bldg., Harlingen, Tex.
Bibby, F. F., Division of Ent., College Station, Tex.
Bigger, J. H., 1102 South Main St., Jacksonville, Ill.
Billings, Samuel C., R.F.D. 1, Silver Spring, Md.
Bilsing, S. W., College Station, Tex.**
Binney, Walter, 780 Second Ave., Chula Vista, Calif.
Bird, Ralph D., Box 250, Brandon, Man., Can.
Birdsall, R. W., Derris Inc., 79 Wall St., New York City.
Biron, Raphael A., 291 Woburn St., R.F.D. 1. North Wilmington, Mass.
Bishopp, F. C., B.E.P.Q., Washington, D. C.**
Bissell, Theo. L., Experiment, Ga.**
Blaisdell, H. L., 20 Sanderson St., Greenfield, Mass.
Blanchard, R. A., Box 32, Urbana, Ill.
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